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भाग 1 सामान्य अपेक्षाएँ

Indian Standard

AUTOMATIC ELECTRICAL CONTROLS FOR HOUSEHOLD AND SIMILAR USE

PART 1 GENERAL REQUIREMENTS

ICS 33.160.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical with IEC 60730-1 : 1999 'Automatic electrical controls for household and similar use — Part 1: General requirements' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Appliances Sectional Committee and approval of the Electrotechnical Division Council.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60038 : 1983 IEC standard voltages	IS 12360 : 1988 Voltage bands for electrical installations including preferred voltages and frequency	Technically Equivalent
IEC 60050 (604) : 1987 International Electrotechnical Vocabulary (IEV) — Chapter 604: Generation, transmission and distribution of electricity — Operation	IS 1885 (Part 70) : 1993 Electrotechnical vocabulary: Part 70 Generation transmission and distribution of electricity — Operation	Identical
IEC 60065 : 1998 Audio, video and similar electronic apparatus — Safety requirements	IS 616 : 2003 Audio, video and similar electronic apparatus — Safety requirements (*third revision*)	Technically Equivalent
IEC 60085 : 1984 Thermal evaluation and classification of electrical insulation	IS 1271 : 1985 Thermal evaluation and classification of electrical insulation (*first revision*)	do
IEC 60099-1 : 1991 Surge arresters — Part 1: Non-linear resistor type gapped arresters for a.c. systems	IS 15086 (Part 1) : 2001 Surge arresters: Part 1 Non-linear resistor type gapped surge arresters for a.c. systems	Identical
IEC 60112 : 1979 Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions	IS 2824 : 1975 Method for determining the comparative tracking index of solid insulating materials under moist conditions (*first revision*)	Technically Equivalent
IEC 60127-1 : 1988 Miniature fuses — Part 1: Definitions for miniature fuses and general requirements for miniature fuse links	IS/IEC 60127 (Part 1) : 1988 Miniature fuses: Part 1 Definitions for miniature fuses and general requirements for miniature fuse links — Specification	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60216-1 : 1990 Guide for the determination of thermal endurance properties of electrical insulating materials — Part 1: General guidelines for ageing procedures and evaluation of test results	IS 8504 (Part 1) : 1994 Guide for determination of thermal endurance properties of electrical insulating materials: Part 1 General guidelines for ageing procedures and evaluation of test results (*first revision*)	Identical
IEC 60227 : 1979 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V	IS 694 : 1990 PVC insulated cables for working voltages up to and including 1 100 V (*third revision*)	Technically Equivalent
IEC 60245-5 : 1994 Rubber insulated cables — Rated voltages up to and including 450/750 V	IS 4289 (Part 1) : 1984 Specification for flexible cables for lifts and other flexible connections: Part 1 Elastomer insulated cables (*first revision*)	do
IEC 60249-1 : 1982 Base materials for printed circuits	IS 5921 (Part 1) : 1993 Metal-clad base materials for printed circuits for use in electronic and telecommunication equipment: Part 1 General requirements and test (*second revision*)	do
IEC 60269-1 : 1986 Low-voltage fuses	IS 13703 (Part 1) : 1993 LV fuses for voltages not exceeding 1 000 V ac or 1 500 V dc: Part 1 General requirements	Identical
IEC 60326-3 : 1991 Printed boards — Part 3: Design and use of printed boards	IS 10424 : 1982 Guide for design and use of printed boards	Technically Equivalent
IEC 60335-1 : 1991 Safety of household and similar electrical appliances — Part 1: General requirements	IS 302-1 : 2008 Safety of household and similar electrical appliances: Part 1 General requirements (*sixth revision*)	do
IEC 60384-14 : 1993 Fixed capacitors for use in electronic equipment — Part 14: Sectional specification: Fixed capacitors for electromagnetic interference and connection to the supply mains	ISQC 302400 : 1994 Fixed capacitors for use in electronic equipment: Sectional specification for fixed capacitors for electromagnetic interference suppression and connection to the supply mains	do
IEC 60384-16 : 1982 Fixed capacitors for use in electronic equipment — Part 16: Sectional specification — Fixed metallized polypropylene film dielectric d.c. capacitors	ISQC 301200 : 1993 Fixed capacitors for use in electronic equipment: Sectional specification for fixed metallized polypropylene film dielectric dc capacitors	do
IEC 60384-17 : 1987 Fixed capacitors for use in electronic equipment — Part 17: Sectional specification — Fixed metallized polypropylene film dielectric a.c. and pulse capacitors	ISQC 301301 : 1993 Fixed capacitors for use in electronic equipment, blank detail specification for fixed metallized polypropylene film dielectric ac and pulse capacitors, assessment level E	do
IEC 60529 : 1989 Degrees of protection provided by enclosures (IP code)	IS 12063 : 1987 Classification of degrees of protection provided by enclosures of electrical equipment	do
IEC 60536 : 1976 Classification of electrical and electronic equipment with regard to protection against electric shock	IS 9409 : 1980 Classification of electrical and electronic equipment with regard to protection against electric shock	do

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60539 : 1976 Directly heated negative temperature coefficient thermistors	IS 9205 (Part 1) : 1979 Directly heated negative temperature co-efficient thermistors: Part 1 General requirements and methods of tests	Technically Equivalent
IEC 60664-1 : 1992 Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests	IS 15382 (Part 1) : 2003[1] Insulation coordination for equipment within low-voltage systems: Part 1 Principles, requirements and tests	Identical
IEC 60664-3 : 1992 Insulation coordination for equipment within low-voltage systems — Part 3: Use of coatings to achieve insulation coordination of printed board assemblies	IS 15382 (Part 3) : 2006[2] Insulation coordination for equipment within low-voltage system: Part 3 Use of coatings, potting or moulding for protection against pollution	do
IEC 60695-2-1/1 : 1994 Fire hazard testing — Part 2: Test methods — Section 1/Sheet 1: Glow-wire end-product test and guidance	IS 11000 (Part 2/Sec 1) : 1984 Fire hazard testing: Part 2 Test methods, Section 1 Glow-wire and guidance	Technically Equivalent
IEC 60695-2-2 : 1991 Fire hazard testing — Part 2: Test methods — Section 2: Needle-flame test	IS 11000 (Part 2/Sec 2) : 1984 Fire hazard testing: Part 2 Test methods, Section 2 Needle-flame test	do
IEC 60707 : 1981 Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source	IS 11731 Methods of test for determination of the flammability of solid electrical insulating materials when exposed to an igniting source: (Part 1) : 1986 Horizontal specimen method (Part 2) : 1986 Vertical specimen method	do
IEC 60738-1 : 1998 Thermistors — Directly heated positive step-function temperature co-efficient — Part 1: Generic specification	ISQC 440000 : 1994 Directly heated positive step-function temperature co-efficient thermistors — Generic specification	do
IEC 60738-1-1 : 1998 Thermistors — Directly heated positive step-function temperature co-efficient — Part 1-1: Blank detail specification — Current limiting application – Assessment level EZ	ISQC 440001 : 1993 Directly heated positive step-function temperature co-efficient thermistors — Blank detail specification — Assessment level E	do
IEC 61000-3-2 : 1998 Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current $\leq$ 16 A per phase)	IS 14700 (Part 3/Sec 2) : 1999 Electromagnetic compatibility (EMC): Part 3 Limits, Section 2 Limits for harmonic current emissions (equipment input current $\leq$ 16A per phase)	do
IEC 61000-3-3 : 1994 Electromagnetic compatibility (EMC) — Part 3: Limits — Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current $\leq$ 16 A	IS 14700 (Part 3/Sec 3) : 1999 Electromagnetic compatibility (EMC): Part 3 Limits, Section 3 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current $\leq$ 16A	Identical

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[1] This standard is identical to IEC 60664-1 : 2002.

[2] This standard is identical to IEC 60664-3 : 2003.

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61000-4-2 : 1995 Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test	IS 14700 (Part 4/Sec 2) : 1999 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 2 Electrostatic discharge immunity test	Technically Equivalent
IEC 61000-4-3 : 1995 Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 3: Radiated, radio-frequency, electromagnetic field immunity test	IS 14700 (Part 4/Sec 3) : 2005 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 3 Radiated, radio-frequency, electromagnetic field immunity test	Identical
IEC 61000-4-4 : 1995 Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test	IS 14700 (Part 4/Sec 4) : 1999 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 4 Electrical fast transient/burst immunity test	Technically Equivalent
IEC 61000-4-8 : 1993 Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test	IS 14700 (Part 4/Sec 8) : 1999 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 8 Power frequency magnetic field immunity test	do
IEC 61058-1 : 1996[1] Switches for appliances — Part 1: General requirements	IS/IEC 61058-1 : 1996 Switches for appliances: Part 1 General requirements	Identical
IEC 61558-2-6 : 1997 Safety of power transformers, power supply units and similar — Part 2-6: Particular requirements for safety isolating transformers for general use	IS/IEC 61558-2-6 : 1997 Safety of power transformers, power supply units and similar: Part 2 Particular requirements, Section 6 Safety isolating transformers for general use	do
CISPR 14 : 1993 Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and electric apparatus	IS 6873 (Part 2) : 1999 Limits and methods of measurement of radio disturbance characteristics: Part 2 Electrical motor-operated and thermal appliances for household and similar purposes, electric tools and electric apparatus (*first revision*)	do
CISPR 22 : 1997 Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement	IS 6873 (Part 7) : 1999 Limits and methods of measurement of radio disturbance characteristics: Part 7 Information technology equipment (*first revision*)	do

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60068-2-75 : 1997	Environmental testing — Part 2-75: Tests — Test Eh: Hammer tests
IEC 60423 : 1993	Conduits for electrical purposes — Outside diameters of conduits for electrical installations and threads for conduits and fittings

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[1] Since revised and adopted as IS/IEC 61058-1 : 2000.

International Standard	*Title*
IEC 60998-2-2 : 1991	Connecting devices for low-voltage circuits for household and similar purposes — Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units
IEC 61000-4-5 : 1995	Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 5: Surge immunity test
IEC 61000-4-6 : 1996	Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 6: Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-4-11 : 1994	Electromagnetic compatibility (EMC) — Part 4: Testing and measuring techniques — Section 11: Voltage dips, short interruptions and voltage variations immunity tests
IEC 61000-4-28 : 1999	Electromagnetic compatibility (EMC) — Part 4-28: Testing and measurement techniques — Variation of power frequency, immunity test
IEC 61210 : 1993	Connecting devices — Flat quick-connect terminations for electrical copper conductors — Safety requirements

Amendment No. 1 to the above International Standard has been given at the end of this publication.

Only the English text of the International Standard has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

AUTOMATIC ELECTRICAL CONTROLS FOR HOUSEHOLD AND SIMILAR USE

PART 1 GENERAL REQUIREMENTS

1 Scope and normative references

1.1 In general, this standard applies to automatic electrical controls for use in, on, or in association with equipment for household and similar use, including controls for heating, air-conditioning and similar applications. The equipment may use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof.

1.1.1 This standard applies to the inherent safety; to the operating values, operating times, and operating sequences where such are associated with equipment safety; and to the testing of automatic electrical control devices used in, or in association with, household or similar equipment.

This standard is also applicable to controls for appliances within the scope of IEC 60335-1.

Throughout this standard the word "equipment" means "appliance and equipment."

This standard does not apply to automatic electrical controls intended exclusively for industrial applications.

This standard is also applicable to individual controls utilized as part of a control system or controls which are mechanically integral with multifunctional controls having non-electrical outputs.

Automatic electrical controls for equipment not intended for normal household use, but which nevertheless may be used by the public, such as equipment intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard.

See also annex J.

1.1.2 This standard applies to automatic electrical controls, mechanically or electrically operated, responsive to or controlling such characteristics as temperature, pressure, passage of time, humidity, light, electrostatic effects, flow, or liquid level, current, voltage or acceleration.

1.1.3 This standard applies to starting relays, which are a specific type of automatic electrical control, intended to switch the starting winding of a motor. Such controls may be built into, or be separate from, the motor.

1.1.4 This standard applies to manual controls when such are electrically and/or mechanically integral with automatic controls.

Requirements for manual switches not forming part of an automatic control are contained in IEC 61058-1.

1.2 This standard applies to controls with a rated voltage not exceeding 690 V and with a rated current not exceeding 63 A.

1.3 This standard does not take into account the response value of an automatic action of a control, if such a response value is dependent upon the method of mounting the control in the equipment. Where a response value is of significant purpose for the protection of the user, or surroundings, the value defined in the appropriate household equipment standard or as determined by the manufacturer shall apply.

1.4 This standard applies also to controls incorporating electronic devices, requirements for which are contained in annex H.

This standard applies also to controls using NTC or PTC thermistors, requirements for which are contained in annex J.

1.5 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60730. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60730 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60038:1983, *IEC standard voltages*

IEC 60050(604):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

IEC 60065:1998, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60099-1:1991, *Surge arresters – Part 1: Non-linear resistor type gapped arresters for a.c. systems*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60127, *Miniature fuses*

IEC 60216-1:1990, *Guide for the determination of thermal endurance properties of electrical insulating materials – Part 1: General guidelines for ageing procedures and evaluation of test results*

IEC 60227, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

IEC 60245, *Rubber insulated cables – Rated voltages up to and including 450/750 V*

IEC 60249, *Base materials for printed circuits*

IEC 60269, *Low-voltage fuses*

IEC 60326, *Printed boards*

IEC 60335-1:1991, *Safety of household and similar electrical appliances – Part 1: General requirements*

IEC 60384-14:1993, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference and connection to the supply mains*

IEC 60423:1993, *Conduits for electrical purposes – Outside diameters of conduits for electrical installations and threads for conduits and fittings*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*

IEC 60536:1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*

IEC 60539:1976, *Directly heated negative temperature coefficient thermistors*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:1992, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coatings to achieve insulation coordination of printed board assemblies*

IEC 60695-2-1/1:1994, *Fire hazard testing – Part 2: Test methods – Section 1/Sheet 1: Glow-wire end-product test and guidance*

IEC 60695-2-2:1991, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*

IEC 60707:1981, *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source*

IEC 60738-1:1998, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1: Generic specification*

IEC 60738-1-1:1998, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1-1: Blank detail specification – Current limiting application – Assessment level EZ*

IEC 60742:1983, *Isolating transformers and safety isolating transformer. Requirements*

IEC 60998-2-2:1991, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*

IEC 61000-3-2:1998, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤ 16 A*

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test. Basic EMC Publication*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test. Basic EMC Publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4: Testing and measuring techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61058-1:1996, *Switches for appliances – Part 1: General requirements*

CISPR 14-1:1993, *Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and electric apparatus*

CISPR 22:1997, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

2 Definitions

For the purpose of this Standard the following definitions apply. Where the terms "voltage" and "current" are used, they imply the r.m.s. values, unless otherwise specified.

2.1 Definitions relating to ratings, voltages, currents and wattages

2.1.1

rated voltage, current, frequency or wattage

voltage, current, frequency or wattage assigned to a control by the manufacturer. For three phase supply, the rated voltage is the line voltage

2.1.2

rated voltage, current, frequency or wattage range

voltage, current, frequency or wattage ranges assigned to the control by the manufacturer and expressed by lower and upper values

2.1.3

working voltage

the highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

NOTE 1 – Transient overvoltages are disregarded.

NOTE 2 – Open-circuit conditions and normal operating conditions are taken into account.

2.1.4

extra-low voltage

nominal voltage not exceeding 42 V between conductors and between conductors and earth, or for three-phase connection not exceeding 42 V between line conductors and 24 V between line conductors and neutral

2.1.5

safety extra-low voltage (SELV)

nominal voltage between conductors and between conductors and earth, not exceeding 42 V between conductors, or in the case of three-phase circuits, not exceeding 24 V between conductors and neutral, the no-load voltage of the circuit not exceeding 50 V and 29 V, respectively

When safety extra-low voltage is obtained from supply mains of higher voltages, it shall be through a safety isolating transformer or a converter with separate windings providing equivalent insulation

The voltage limits are based on the assumption that the safety isolating transformer is supplied at its rated voltage.

In some countries, the limit for safety extra-low voltage is 30 V.

2.1.6

safety isolating transformer

transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to double or reinforced insulation, and which is intended to supply safety extra-low voltage circuits

2.1.7

same polarity

relationship between live parts such that an interconnection between them allows a flow of current through a load, and which current is thus limited by the load

2.1.8

opposite polarity

relationship between two live parts such that an interconnection between them allows a flow of current which is limited by the impedance of the electrical supply circuit

2.1.9

isolated limited secondary circuit

circuit from an isolated secondary winding of a transformer having a maximum capacity of 100 VA and an open-circuit secondary voltage rating not exceeding 1 000 V

2.1.10

pilot duty

class of operation in which the ultimate electrical load is controlled by an auxiliary means such as a relay or contactor

2.1.11

transient overvoltage

a short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped [IEV 604-03-13]

2.1.12

rated impulse voltage

an impulse withstand voltage assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against overvoltages

2.1.13

overvoltage category

a numeral characterizing a transient overvoltage condition

NOTE – Overvoltage categories I, II, III, and IV are used. See annex L.

2.2 Definitions of types of control according to purpose

2.2.1

electrical control (hereinafter referred to as "control")

device used in, on or in association with an equipment for the purpose of varying or modifying the output from such equipment, and which embodies the aspects of initiation, transmission and operation. At least one of these aspects shall be electrical or electronic

2.2.2

manual control

control in which the initiation is by actuation and in which the transmission and the operation are both direct and without any intentional time delay

2.2.3

automatic control

control in which at least one aspect is non-manual

2.2.4

sensing control

automatic control in which initiation is by an element sensitive to the particular activating quantity declared; for example, temperature, current, humidity, light, liquid level, position, pressure or velocity

2.2.5

thermally operated control

automatic control in which the transmission is by a thermal prime mover

2.2.6

thermostat

cycling temperature sensing control, which is intended to keep a temperature between two particular values under normal operating conditions and which may have provision for setting by the user

2.2.7

temperature limiter

temperature sensing control which is intended to keep a temperature below or above one particular value during normal operating conditions and which may have provision for setting by the user

A temperature limiter may be of the automatic or of the manual reset type. It does not make the reverse operation during the normal duty cycle of the appliance.

2.2.8

thermal cut-out

temperature sensing control intended to keep a temperature below or above one particular value during abnormal operating conditions and which has no provision for setting by the user

A thermal cut-out may be of the automatic or of the manual reset type.

Normally a thermal cut-out will provide a type 2 action.

2.2.9 Void

2.2.10

energy regulator

self-cycling control which alters the energy to a load and which may incorporate means for setting by the user to change the average energy supplied

The ratio of the on-time, to the on-plus-off-time, determines the average energy supplied.

2.2.11

time-based control

automated control in which the transmission is effected by a time-based prime mover or a time-based electrical circuit

2.2.12

electrically operated control

automatic control in which the transmission is effected by an electrical prime mover and in which the operation controls an electric circuit, and is without intentional significant time-delay

An example is a relay.

A slugged-relay may be either an electrically operated control, or a time-based control by agreement between testing authority and manufacturer.

2.2.13

timer

time-based control which requires actuation before the next cycle can take place

During a cycle it may require an external electrical or mechanical signal before moving from a rest position to allow the cycle to continue. An example is a programmer.

2.2.14

time switch

time-based control which continues with a subsequent cycle when the preceding one has been completed

An example is a 24 h control on a storage heater.

2.2.15

motor protector

automatic control that is specifically intended to protect the windings of an electric motor from overheating

2.2.16

thermal motor protector

automatic control, built-in or on a motor, that is specifically intended to protect the motor against overheating due to running overload and failure to start. The control carries motor current and is sensitive to motor temperature and current

The control is capable of being reset (either manually or automatically) when its temperature falls to the reset value.

2.2.17
electrically operated valve
automatic control in which the transmission is effected by an electrical prime mover and in which the operation controls the flow of a liquid or a gas

2.2.18
electrically operated mechanism
automatic control in which the transmission is effected by an electrical prime mover in which the operation controls a mechanical device

An example is an electrically operated interlock for a spin dryer lid.

An electric motor is not included in this definition.

2.2.19
operating control
control which starts or regulates the equipment during normal operation

2.2.20
protective control
control, the operation of which is intended to prevent a hazardous situation during abnormal operation of the equipment

2.3 Definitions relating to the function of controls

2.3.1
initiation
alteration to that aspect of a control which is required to produce transmission and operation

2.3.2
transmission
essential coupling between initiation and operation which is required to enable the control to fulfil its purpose

2.3.3
operation
change in that aspect of a control which modifies the input to the equipment or part of the equipment

2.3.4
automatic action
that action of an automatic control in which the transmission and operation are produced by initiation which is not the result of actuation

2.3.5
slow-make slow-break automatic action
mode of operation where the rate of contact make and/or break is directly proportional to the rate of change of the activating quantity, or to the speed of movement of a prime mover

This action may be applicable to either the make, or the break, or both.

2.3.6
manual action
that action of an automatic control or of a manual control in which the transmission and operation are produced by initiation which is the result of actuation

2.3.7
actuation

movement of the actuating member of the control by the user, by hand, by foot or by any other human activity

2.3.8
located position

position of the actuating member to which it will return if it is released after being moved slightly

2.3.9
intermediate position

any position of any actuating member which is adjacent to a located position, and in which the actuating member will remain and in which the operation of the control is intermediate

2.3.10
activating quantity

physical characteristic of a medium, the variation or stability of which is being sensed

2.3.11
operating value

value of the relevant temperature, pressure, current, etc. at which a sensing control operates on a rise or fall of the activating quantity

2.3.12
operating time

duration of time, or the difference of time, between any two functions, electrical or mechanical, occurring during the automatic action of a time-based control

2.3.13
operating sequence

intended sequence, order or pattern in which the operation of the electrical or mechanical functions of a control are intended to occur as a result of either an automatic or a manual action of a control

It includes the pattern of opened or closed contacts in any located position, intermediate position or position of setting by manufacturer or user.

2.3.14
response value

operating value, the operating time or the operating sequence which relates a control to a particular equipment

2.3.15
trip-free

automatic action, with a reset actuating member, in which the automatic action is independent of manipulation or position of the reset mechanism

2.3.16
leakage current

all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of a device and earth or other exposed conductive surfaces of a device

2.3.17
setting
mechanical positioning of a part of a control in order to select an operating value

2.3.18
setting by the control manufacturer
any setting carried out by the control manufacturer which is not intended to be altered by the equipment manufacturer, the installer or the user

2.3.19
setting by the equipment manufacturer
any setting carried out by the equipment manufacturer which is not intended to be altered by the installer or the user

2.3.20
setting by the installer
any setting carried out by the installer, as instructed by the equipment manufacturer or the control manufacturer, and which is not intended to be altered by the user

2.3.21
setting by the user
any selection of an operating value by actuation performed by the user

2.3.22
set point
value selected by setting

2.3.23
adjustable set point
multiple values, within a declared range of values, which can be selected by setting

2.3.24
duty cycle
all automatic and manual actions involved in one start-to-finish operation of the controlled equipment

2.3.25
cycle of contact operation
one contact make and one subsequent contact break action, or one contact break and one subsequent contact make action

2.3.26
operating differential
difference between the upper and lower values of the operating value

2.3.27
adjustable differential
ability to change or alter the operating differential within rated limits by operation of a manually actuated mechanism

2.3.28
fixed differential
operating differential which cannot be changed from the manufacturer's setting

2.3.29
maximum working pressure (maximum rated pressure)
declared maximum line or system working pressure to which the control or parts thereof may be subjected

2.3.30
T_{max}
the declared maximum continuous ambient temperature to which the switch head is intended to be exposed during normal operation

2.4 Definitions relating to disconnection and interruption

Some controls may incorporate more than one form of circuit disconnection or interruption.

2.4.1
all-pole disconnection
for single-phase a.c. appliances and for d.c. appliances, disconnection of both supply conductors by a single switching action or, for appliances to be connected to more than two supply conductors, disconnection of all supply conductors, except the earthed (grounded) conductor, by a single switching action

The protective earthing conductor is not considered to be a supply conductor.

2.4.2
full-disconnection
contact separation in all supply poles other than earth so as to provide the equivalent of basic insulation between the supply mains and those parts intended to be disconnected

There are electric strength and dimensional requirements.

Where the number of poles on the control is equal to the number of supply poles of the appliance to which it is connected, full-disconnection provides all-pole disconnection.

See also annex H.

2.4.3
micro-disconnection
adequate contact separation in at least one pole so as to provide functional security

There is a requirement for the electric strength of the contact gap but no dimensional requirement

Micro-disconnection denotes that for non-sensing controls the function controlled by the disconnection is secure, and that for sensing controls is secure between the limits of activating quantity declared in requirement 36 of table 7.2.

See also annex H.

2.4.4
micro-interruption
interruption of a circuit by contact separation, by a cycling action or by a non-cycling action which does not provide full-disconnection or micro-disconnection

There are no electric strength or dimensional requirements for the contact gap

See also annex H.

2.4.5
OFF position
position providing a visible or implied indication of a full-disconnection or micro-disconnection.

2.4.6 See annex H.

2.5 Definitions of types of control according to construction

2.5.1
integrated control

control which is dependent on its correct mounting and fixing in an equipment, and which can only be tested in combination with the relevant parts of the equipment

The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Integrated control also denotes a control which is part of a more complex control (electrical or non-electrical).

2.5.2
incorporated control

control intended for incorporation in, or on, an equipment, but which can be tested separately

The fact that an incorporated control can be tested separately does not imply that it may not be tested in an equipment as specified in 4.3.1.1.

The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Incorporated control also denotes a control intended for incorporation in or on a more complex control (electrical or non-electrical).

2.5.3
in-line cord control

separately cased control intended to be connected to the supply and to the equipment by means of flexible cords, equipment inlets or socket-outlets; and is intended to be manually actuated

2.5.4
free-standing control

in-line cord control intended to stand on a table or on the floor. It may be actuated by hand, by foot or by other similar human activity

2.5.5
independently mounted control

a control intended for permanent connection to fixed wiring, but intended to be mounted away from the controlled equipment. It may be either:

- for surface mounting such as on to a wall;
- for flush mounting, such as into a wall cavity, when installation shall be possible from the front;
- for panel mounting, such as onto or into a control panel, when installation may be from the rear

2.5.6
pull-cord actuated control

control intended to be mounted in, or on, an equipment and actuated by means of a pull-cord

2.5.7 to **2.5.10** See annex H.

2.5.11
two-step actuation

sequential performance of two distinct movements of the actuating member

2.6 Definitions of type of automatic action of a control according to test procedure

2.6.1

type 1 action

automatic action for which the manufacturing deviation and the drift of its operating value operating time or operating sequence have not been declared and tested under this standard

A type 1 action is subclassified as specified in 6.4.

2.6.2

type 2 action

automatic control for which the manufacturing deviation and the drift of its operating value. operating time or operating sequence have been declared and tested under this standard

A type 2 action is subclassified as specified in 6.4.

2.7 Definitions relating to protection against electric shock

2.7.1

live part

conductive part intended to be energized in normal use, including a neutral conductor. but by convention not a PEN conductor

2.7.1.1

hazardous live part

a live part which, under certain conditions of external influences. can give an electric shock

2.7.2

class 0 control

control in which protection against electric shock relies upon basic insulation. This implies that there are no means for the connection of accessible conductive parts, if any, to the protective conductor in the fixed wiring of the installation; reliance in the event of a failure of the basic insulation is placed upon the environment

In some countries class 0 controls are not allowed.

An earthing terminal is only allowed if it is for continuity or functional (as distinct from protective) purposes

2.7.3

class 0I control

in-line cord control having at least basic insulation throughout and provided with an earthing terminal but with a non-detachable cord without earthing conductor, and a plug without earthing contact which cannot be introduced into a socket-outlet with earthing contact

In some countries class 0I controls are not allowed.

An earthing terminal is only allowed if it is for continuity (as distinct from protective) purposes

2.7.4

class I control

control in which protection against shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation

This provision includes a protective conductor as part of the flexible cord or cable. When class 1 controls are fitted with a two-core flexible cord or cable; provided that it is fitted with a plug which cannot be introduced into a socket-outlet with earthing contact, the protection is then equivalent to that of class 0, but the earthing provisions of the equipment in all other respects should fully comply with the requirements of class I.

Class I controls may have parts with double insulation, or parts operating at safety extra-low voltage.

2.7.5

class II control

control in which protection against electric shock does not rely on basic insulation only, but in which additional protective precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions. Such a control may be one of the following types:

Class II controls may have parts operating at safety extra-low voltage.

2.7.5.1

insulation-encased class II control

a control having a durable and substantially continuous enclosure of insulation material which envelopes all metal parts, with the exception of small parts, such as name plates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation. Such a control is called an insulation-encased class II control

2.7.5.2

metal-encased class II control

a control having a substantially continuous metal enclosure in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable. Such a control is called a metal-encased class II control

2.7.5.3

combination insulation-encased/metal-encased class II control

a control which is a combination of the types described in 2.7.5.1 and 2.7.5.2

The enclosure of an all-insulated class II control may form a part or the whole of the supplementary insulation or of the reinforced insulation. If a control with double insulation and/or reinforced insulation throughout has an earthing terminal or earthing contact, it is deemed to be of class 0I or class I construction.

2.7.6

class III control

control in which protection against electric shock relies on supply at safety extra-low voltage (SELV) and in which voltages higher than those of SELV are not generated

An earthing terminal is only allowed if it is for continuity or functional (as distinct from protective) purposes.

2.7.7

detachable part

part which can be removed or opened without the aid of a tool and which does not comply with the test of 11.11.1.5

2.7.8

accessible part or surface

part or surface which can be touched by the test finger of figure 2, when the control is mounted as in normal use, and after detachable parts have been removed

2.7.9
operational insulation

insulation between live parts which have a potential difference between them, and which insulation is necessary for the correct operation of the control or controlled equipment (L-L)

This was formerly part of that insulation referred to as functional insulation.

In 2.7.9 through 2.7.12 the following abbreviations are used:

L live part;

A accessible part (either conductive or an insulating surface);

I intermediate part.

2.7.10
basic insulation

insulation applied to live parts to provide basic protection against electric shock (L-A or L-I). Basic insulation includes insulation between live parts and:

- intermediate conductive parts or metal foil over intermediate insulating surfaces (class II situation);
- accessible conductive parts (class 0, 0I, I situations);
- conductive parts connected to accessible conductive parts (class 0, 0I, I situations);
- metal foil over accessible insulating surfaces (class 0 situation)

This was formerly part of that insulation referred to as functional insulation.

2.7.11
supplementary insulation

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation (I-A). It includes insulation between intermediate conductive parts, or metal foil over intermediate insulating surfaces, and:

- accessible conductive parts (class II situation);
- conductive parts connected to accessible conductive parts (class II situation);
- metal foil over accessible insulating surfaces (class II situation)

2.7.12
reinforced insulation

single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard (L-(I)-A). It includes insulation between live parts and:

- accessible conductive parts (class II situation);
- conductive parts connected to accessible conductive parts (class II situation);
- metal foil over accessible insulating surfaces (class II situation)

The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

2.7.13
double insulation

insulation comprising both basic insulation and supplementary insulation (class II situation).

2.7.14 See annex H.

2.8 Definitions relating to component parts of controls

2.8.1
sensing element
that part of the control which is intended to be exposed to the influences of the activating quantity to which the automatic action of a sensing control responds

2.8.2
switch head
complete control, except for any sensing element

If by construction it is impossible to distinguish between the switch head and the sensing element, then the whole control is considered to be the sensing element.

2.8.3
actuating member
that part which is manually moved, pulled, pushed or turned to cause initiation of a control action, or for setting by the user

The term "actuating member" does not include any device such as a set-screw used for setting by the manufacturer if such a device is adequately locked against further movement, or if a tool is required for such setting by the manufacturer.

2.8.4
actuating means
any part which connects the actuating member to the mechanism of the control

2.8.5
pull-cord
flexible actuating member which is pulled to cause actuation

2.8.6
prime mover
any device used to produce the mechanical energy required to provide the transmission for an automatic control, such as an electrically operated control, an electrically operated valve, an electrically operated mechanism or a time-based control

It may be a mechanical storage device (for example a clockwork spring), an electro-magnetic device (for example an electric motor, or stepping solenoid), an electro-thermal device (for example the heating element of an energy regulator) or any other mechanism producing mechanical energy.

2.8.7
clutch
mechanical device by which an actuating member can override either a prime mover or an activating quantity, causing or allowing the initiation or cancellation of an action

2.8.8
cover or cover plate
part which is accessible when the control is mounted as in normal use and which can be removed only with the aid of a tool. It shall not require the use of a special purpose tool for its removal

2.8.9
screwless fixed part (or component)
accessible part (or component) which, after attachment, installation, mounting or assembly into or onto an equipment or another component, or to a specially prepared support, is retained in position by positive means which do not depend on screws. Disassembly or removal may require the use of a tool, either applied directly to the part (or component), or to obtain access to the retaining means

The following are some examples of parts which are not regarded as screwless fixed parts or components:

- parts of components fixed permanently by rivets, glueing or similar means;
- flat, push-on connectors;
- screwless terminals;
- standard plugs and socket-outlets;
- standard appliance couplers, even if such have additional latching devices to prevent a single action uncoupling;
- the replacement of a lamp in a bayonet type lampholder;
- twist-lug construction;
- friction-fit construction.

2.9 Definitions of types of terminals and terminations of controls

2.9.1

pillar terminal

terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws. The clamping pressure may be applied directly by the shank of the screw, or through an intermediate clamping member to which pressure is applied by the shank of the screw (see figure 11)

2.9.2

screw terminal

terminal in which the conductor is clamped under the head of the screw. The clamping pressure may be applied directly by the head of the screw, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see figure 10)

2.9.3

stud terminal

terminal in which the conductor is clamped under a nut. The clamping pressure may be applied directly by a suitably shaped nut, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see figure 10)

2.9.4

screwless terminal

terminal in which the connection of the conductor is achieved directly or indirectly by means of springs, wedges, eccentrics, cones or the like

The following are not regarded as screwless terminals:

- terminals requiring the fixing of special devices to the conductors before clamping them in the terminal, for example flat push-on connectors;
- terminals requiring wrapping of the conductors, for example those with wrapped joints;
- terminals providing direct contact to the conductors by means of edges or points penetrating the insulation.

2.9.5

flat push-on connector

assembly of a tab and a receptacle enabling the connection, at will, of a core or conductor to a control or to another core or conductor

2.9.6

receptacle

female part of a flat push-on connector intended to be permanently attached to a core or conductor (see figure 16)

2.9.7

tab

male part of a flat push-on connector (see figures 14 and 15)

2.9.8

in-line tab

tab intended to be permanently attached to a core or conductor

2.9.9

tab forming part of a control

tab permanently attached to, or an integral part of, a control

2.9.10

termination

part by which a conductor can be connected to a control in such a way that its replacement requires either a special purpose tool, a special process or a specially prepared end of the conductor

Soldering requires a special purpose tool. Welding requires a special process. A cable lug attached to a conductor is a specially prepared end.

2.9.11

solder termination

termination in which the conductor is secured by a mechanical means, and the circuit continuity is assured by solder

2.9.12

saddle terminal

terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts (see figure 13a)

2.9.13

lug terminal

screw terminal or stud terminal, intended to clamp a cable lug or bar by means of a screw or nut (see figure 13b)

2.9.14

mantle terminal

terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut. The conductor is clamped against the base of the slot by a suitably shaped washer under the nut, by a central peg if the nut is a cap nut or equally effective means for transmitting the pressure from the nut to the conductor within the slot (see figure 12)

2.10 Definitions relating to the connections to controls

2.10.1

external conductor

any cable, flexible cord, core or conductor, a part of which is external to an in-line cord control, an independently mounted control or to an equipment in or on which a control is mounted

Such a conductor may be a supply lead, a function cord or interconnecting cord between different parts of an equipment; or it may form part of the fixed wiring.

2.10.2

fixed wiring

any external conductor which is permanently secured to the fabric of the building such that, in normal use at the point at which the conductor enters the equipment or control, there is no likelihood of any strain being applied to the conductor

Such securing to the fabric of the building may be, for example, by the enclosing of conductors in conduit, burying cables in walls, adequately fixing cables or cords to walls or other surfaces, etc.

2.10.3

internal conductor

any cable, flexible cord, core or conductor which is neither an external conductor, nor an integrated conductor

An example is a conductor inside the equipment to interconnect the control and the equipment.

2.10.4

integrated conductor

conductor which is inside a control, or is used to permanently interconnect terminals or terminations of a control

2.10.5

detachable cord

flexible external cord connected to a control or equipment by means of an equipment inlet, or plug and socket arrangement

2.10.6

non-detachable cord

flexible external conductor connected to, or assembled to, a control according to one of the following methods

2.10.6.1

type X attachment

method of attachment such that the cord can be easily replaced without special-purpose tools, using standard cords without any special preparation

2.10.6.2

type M attachment

method of attachment such that the cord can be easily replaced without special purpose tools, but is intended to use only a special cord, such as one with a moulded-on cord guard, or one with special prepared ends

This attachment method does not apply if it is possible to fit a standard cord during servicing unless such is permitted by a particular equipment standard.

2.10.6.3

type Y attachment

method of attachment of the supply cord such that any replacement is intended to be made by the manufacturer, its service agent or a similar qualified person

2.10.6.4

type Z attachment

method of attachment such that the flexible cable or cord cannot be replaced without breaking or destroying a part of the control

2.10.7

flying lead (pigtail)

wire or wires intended for the connection of the control, with one end permanently connected to the control by the control manufacturer

2.11 Definitions relating to the performance of Type 2 actions

2.11.1
manufacturing deviation
maximum difference of operating value, operating time or operating sequence which is claimed between any two controls, supplied by the manufacturer to a unique type reference, when tested as submitted and in the same manner

The difference may be related to an absolute value if permitted by the appropriate subclause of clause 15.

2.11.2
drift
maximum alteration of operating value, operating time or operating sequence of any one sample which can occur when it is tested under the conditions specified in this standard

The alteration may be related to an absolute value, or combined with the manufacturing deviation, if permitted by the appropriate subclause of clause 15.

2.12 Definitions relating to the requirements for creepage distances and clearances

2.12.1
clearance
shortest distance through air between two conductive parts, or between a conductive part and a metal foil in contact with a surface of insulating material

The method of measurement is detailed in annex B and figure 17.

2.12.2
creepage distance
shortest distance along the surface of the insulating material between two conductive parts, or between a conductive part and a metal foil in contact with any accessible surface of insulating material

The method of measurement is detailed in annex B and figure 17.

2.12.3 Void

2.12.4 Void

2.12.5 Void

2.12.6 Void

2.12.7 Void

2.12.8
pollution
any addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

2.12.9 environment

2.12.9.1
macro-environment
the environment of the room or other location in which the equipment is installed or used

2.12.9.2
micro-environment
the immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

2.12.9.3
pollution degree
a numeral characterizing the expected pollution of the micro-environment

Note – Pollution degrees 1, 2, 3, and 4 are used. See annex N.

2.13 Miscellaneous definitions

2.13.1
unique type reference
marking such that by quoting it in full to the manufacturer of the control, a replacement can be supplied which will be fully interchangeable with the original, electrically, mechanically, dimensionally and functionally

2.13.2
tool
screwdriver, a coin or any other object which may be used to operate a nut, a screw or similar part

2.13.3
special-purpose tool
tool which is unlikely to be readily available in a normal household, for example, a key for a hexagonal socket-headed screw. Tools such as coins, screwdrivers and spanners intended to operate square, or hexagonal nuts, are not special-purpose tools

2.13.4
normal use
use of the control, or its associated equipment, for the purpose for which it was made, and in the manner intended by the manufacturer

Normal use includes any overload, or abnormal operating conditions specified in the equipment standard

Normal use does not include any process which is necessary to maintain the control or equipment in good order, even though this may be carried out by the user according to the manufacturer's instructions

2.13.5
user maintenance
any periodic process necessary to maintain the control, or equipment, in good order, for which details are given in the manufacturer's instructions to the user

2.13.6
servicing
any process necessary to maintain a control, or equipment, in good order, that would be done by a competent person, such as in a workshop, by an electrician or by a service organization. This includes replacing a flexible cord, thermal link or the like

2.13.7
manufacturer servicing
servicing which can only be done by the manufacturer, or his accredited serviceman. This may be due to the need for special tools, or special instrumentation, and includes the setting by the manufacturer

2.14 Definitions relating to manufacturer and user

2.14.1
control manufacturer
manufacturer of the control

2.14.2
equipment manufacturer
manufacturer of equipment in which, on which, or together with which the control is used

In Canada and the USA, the equipment manufacturer is indicated as the OEM (original equipment manufacturer). The OEM receives controls from control manufacturers for integration or incorporation into equipment.

2.14.3
installer
person qualified to install the control and possibly the associated equipment

2.14.4
user
one who uses the control with the aid of documentation (user maintenance) during its normal life. The user is considered a layman.

2.15 Definitions pertaining to thermistors

See annex J.

2.16 Definitions relating to the structure of controls using software

See annex H.

2.17 Definitions relating to error avoidance in controls using software

See annex H.

2.18 Definitions relating to fault/error control techniques for controls using software

See annex H.

2.19 Definitions relating to memory tests for controls using software

See annex H

2.20 Definitions of software terminology – General

See annex H.

3 General requirements

Controls shall be so designed and constructed that in normal use they function so as not to cause injury to persons or damage to surrounding property, even in the event of such carelessness as may occur in normal use.

In general, compliance is checked by carrying out the relevant tests specified in this standard and the appropriate part 2.

4 General notes on tests

Tests according to this standard are type tests.

4.1 Conditions of test

4.1.1 *Unless otherwise specified in this standard, the samples are tested as delivered, having been mounted as declared by the manufacturer, but, when significant, in the most unfavourable position.*

4.1.2 *If the test results are influenced by the room temperature, this shall be maintained at (20 ± 5) °C, except that in cases of doubt, it shall be maintained at (23 ± 2) °C, unless otherwise specified in a particular clause.*

4.1.3 *Actuating members are placed in the most unfavourably located position, intermediate position or position of setting by the user, unless other instructions are given in a particular clause.*

4.1.4 *Unless otherwise specified in this standard, the tests are carried out in the order of the clauses of this standard.*

See also annex H.

4.1.5 *During the tests of this standard, actuation may be performed by test equipment if so desired, except for the high-speed tests of 17.12.*

4.1.6 *During and for the purpose of the tests of this standard, other than for the tests of 17.12, the actuating means can be used to actuate the control, if an actuating member is not supplied by the manufacturer.*

4.1.7 *The rates of temperature change declared in 7.2 and used in clause 17 (that is α_1, β_1, α_2 and β_2) shall have test tolerances of ±12 K/h.*

For other activating quantities, the minimum and/or maximum rates of change declared in requirement 37 of table 7.2 and used in clause 17 (that is α_1, β_1, α_2 and β_2) shall have test tolerances as specified in the appropriate part 2.

4.1.8 *In all tests the measuring instruments or the measuring means shall be such as not to affect appreciably the value being measured.*

4.1.9 to **4.1.11** See annex H.

4.2 Samples required

4.2.1 *One sample is used for the tests in clauses 5 to 11 and 18 to 23 inclusive. A set of three samples is subjected to the remaining tests.*

If one sample does not comply with the tests of clauses 12 to 17 inclusive, the test which caused the non-compliance, and those preceding which may have influenced the result of that test, are repeated on another set of identical samples, all of which shall then comply with the repeated tests.

The manufacturer may submit, together with the first set of samples, the additional set or sets which may be wanted should one sample not comply. The testing authority will then, without further request, test the additional samples, and will only reject if a further non-compliance occurs. If the additional sets of samples are not submitted at the same time, a non-compliance of one sample may entail a rejection.

In some countries only 1 sample is used for the tests of clauses 12 to 17 inclusive and the sample tested must comply.

4.2.2 *Void*

4.2.3 *Additional samples may be required for some destructive tests of this standard.*

4.2.4 *Controls which are intended to meet the requirements of more than one part 2 document shall, in general, be tested to each part 2 separately.*

By agreement between manufacturer and testing authority, requirements and tests which are common to more than one part 2, need only be checked once, unless the common tests may influence the results of any specific tests.

4.3 Instructions for test

4.3.1 According to submission

4.3.1.1 *Controls, if submitted in or with an equipment, may either be tested in or with the equipment, in which case they are classified as for declared specific load or tested separately, in which case they may be classified as for declared specific load, resistive load or resistive and inductive load. In either of the latter two cases, the current in the appropriate circuit when the equipment is operating under normal load, is regarded as the rated current of the circuit.*

4.3.1.2 *For all controls submitted, in, on or with an equipment, all other relevant information as required by 7.2 may be obtained by inspection and measurement of the submitted equipment.*

4.3.1.3 *Integrated controls are classified as for declared specific load and are tested in the equipment, or part thereof, for which they are intended.*

4.3.1.4 *Controls not submitted in or with an equipment are tested separately.*

4.3.1.5 *Controls for use with non-detachable cords are tested with the appropriate cord connected.*

4.3.2 According to rating

4.3.2.1 *Controls for a.c. only are tested with a.c. at rated frequency if declared; those for d.c. only are tested with d.c. and those for a.c./d.c. at the more unfavourable supply.*

4.3.2.2 *Controls for a.c. only, which are not declared for a rated frequency, are tested at either 50 Hz or 60 Hz whichever is the more unfavourable. Controls with a rated frequency within a declared range other than 50 Hz to 60 Hz are tested at the most unfavourable frequency within the marked or declared range.*

4.3.2.3 *When testing controls intended for d.c. only, the possible influence of polarity on the operation of the control is taken into consideration.*

4.3.2.4 *For controls with different a.c. and d.c. ratings the tests for clauses 12, 13, 14 and 17, are made on two sets of samples, one being tested according to the a.c. rating, and the other according to the d.c. rating.*

At the option of the testing authority a reduced number of tests may be made to cover the various ratings.

4.3.2.5 *Unless otherwise specified, controls declared for one or more voltage ranges, shall be tested at the most unfavourable voltage within the declared range, and this voltage being multiplied by the factor indicated in the appropriate clause (see 4.3.2.7).*

4.3.2.6 *For controls marked or declared for more than one rated voltage or rated current, the tests of clause 17 are made on sets of samples for each combination of rated voltage and rated current.*

At the option of the testing authority a reduced number of tests may be made to cover the various ratings.

4.3.2.7 *For controls declared for a voltage range, tests are made on one set of samples at each limit of the range, unless the difference between the limits does not exceed 10 % of the mean value of the range, in which case the tests are made on one set of samples at the upper limit of the range.*

4.3.2.8 *Controls intended to be operated from a specific supply, are tested with that specific supply.*

4.3.3 According to protection against shock

4.3.3.1 *If in class 0, class 0I or class I controls, or in controls for class 0, class 0I or class I equipment, it is necessary to have parts with double insulation or reinforced insulation, such parts are checked for compliance with the appropriate requirements specified for class II controls.*

4.3.3.2 *In any class I control, and in any control used in a class I equipment, unearthed accessible metal or accessible insulating surfaces shall be provided with insulation complying with the requirements for a class II control (see 9.1.1).*

4.3.3.3 *If in class 0, class 0I, class I or class II controls, or controls for class 0, class 0I, class I or class II equipment, it is necessary to have parts operating at safety extra-low voltage, such parts are also checked for compliance with the appropriate requirements specified for class III controls.*

4.3.4 According to manufacturing variants

4.3.4.1 *Controls which are otherwise identical but which may be set by the manufacturer, or which may, by the inclusion at the manufacturing stage of alternative components or parts produce various operating values, operating times or operating sequences, are for the purpose of this standard normally treated as a single submission. Normally, controls set to the most arduous condition will be sufficient. However, the testing authority may require extra samples, set to other values, where it can be clearly shown that these are necessary to allow approval of the whole range.*

4.3.4.2 *In these cases due attention shall be paid to possible variations in manufacturing deviation and drift of any operating value, operating time or operating sequence, and, for sensing controls, to the minimum and maximum acceptable rates of rise and fall of the appropriate activating quantity which may be applicable to different parts of the range.*

4.3.5 According to purpose

4.3.5.1 *Multi-purpose controls shall, according to 6.3, in general be tested for each purpose separately. During the tests for any one purpose, the activating quantities and prime movers applicable to all other purposes, shall be maintained constant at the most arduous value or position within the declared range or ranges.*

4.3.5.2 *Such controls without an appropriate section of clause 17 shall be tested in a manner agreed between the manufacturer and the testing authority so that the essential intended operating values, operating times and operating sequences are tested.*

4.3.5.3 *Any control with a purpose not classified in 6.3, or in the appropriate part 2, may be tested and approved to this specification, except for clause 17. A test schedule for clause 17 shall be based, wherever possible, on the intent of that clause and shall be agreed between the manufacturer and the testing authority.*

4.3.5.4 *See annex J.*

5 Rating

5.1 Maximum rated voltage

The maximum rated voltage is 690 V.

5.2 Maximum rated current

The maximum rated current is 63 A.

5.3 Compliance

Compliance with 5.1 and 5.2 is checked by the information requirements in clause 7.

6 Classification

A control is classified:

6.1 According to nature of supply

6.1.1 Control for a.c. only

A control for a.c. only may be used on a d.c. circuit provided that the current does not exceed 10 % of the rated current for a.c., or 0,1 A, whichever is smaller.

Additional tests may be required to establish the d.c. rating.

6.1.2 Control for d.c. only.

6.1.3 Control for a.c. and d.c.

6.1.4 Control for specific supplies or multiple supplies.

6.2 According to type of load to be controlled by each circuit of the control

A control having more than one circuit need not have the same classification for each circuit.

6.2.1 Circuit for a substantially resistive load with a power factor not less than 0,95.

Such circuits may be used for an inductive load, provided that the power factor is not less than 0,8, and the inductive load does not exceed 60 % of the current rating for the resistive load. Such circuits may also be used for other reactive loads provided that the reactive current does not exceed 5 % of the rated resistive current, and that the load is not greater than 10 VA.

6.2.2 Circuit suitable for either a resistive load or for an inductive load with a power factor not less than 0,6 or a combination of both.

An example is a circuit in a fan-heater which incorporates both a heating element and a motor.

Circuits intended for inductive loads only may either be classified under this subclause by declaring that the resistive load is equal to the inductive load, or may be classified as for a declared specific load.

6.2.3 Circuit for declared specific load

Examples are circuits for tungsten filament or fluorescent lamp loads, highly inductive loads with a power factor of less than 0,6, capacitive loads, and contacts intended to be operated off load.

6.2.4 Circuit for a current less than 20 mA

Examples are circuits for neon indicators and other signal lamps.

6.2.5 Circuit for a.c. motor load whose characteristics are defined by the control manufacturer's declaration.

6.2.6 Circuit for pilot load.

6.3 According to their purpose

A control may be classified for more than one purpose, in which case it is referred to as a multi-purpose control.

Any manual action of an automatic control or a separate manual action being integral with an automatic control is not classified according to this subclause.

6.3.1 – thermostat;

6.3.2 – temperature limiter;

6.3.3 – thermal cut-out;

6.3.4 Void

6.3.5 – energy regulator;

6.3.6 – timer;

6.3.7 – time switch;

6.3.8 – manual control;

6.3.9 – sensing control (other than one covered by 6.3.1 through 6.3.4);

6.3.10 – electrically operated control;

6.3.11 – motor protector;

6.3.11.1 – thermal motor protector;

6.3.12 – electrically operated valve;

6.3.13 – electrically operated mechanism;

6.3.14 – protective control;

6.3.15 – operating control.

Further classification can be found in the appropriate part 2.

6.4 According to features of automatic action

6.4.1 – Type 1 action;

6.4.2 – Type 2 action.

6.4.3 Type 1 actions and Type 2 actions are further classified according to one or more of the following constructional or operational features:

These further classifications are only applicable if the relevant declarations have been made and any appropriate tests completed.

An action providing more than one feature may be classified by a combination of the appropriate letters, for example, Type 1.C.L. or Type 2.A.E.

A manual action is not classified according to this subclause.

6.4.3.1 – full-disconnection on operation (Type 1.A or 2.A);

6.4.3.2 – micro-disconnection on operation (Type 1.B or 2.B);

6.4.3.3 – micro-interruption on operation (Type 1.C or 2.C);

See also annex J.

6.4.3.4 – a trip-free mechanism which cannot even momentarily be reclosed against the fault (Type 1.D or 2.D);

6.4.3.5 – a trip-free mechanism in which the contacts cannot be prevented from opening or maintained closed against a continuation of the fault (Type 1.E or 2.E);

An example is a current-sensing control which has to be reclosed or can be reclosed momentarily to detect that the excess current fault still exists.

6.4.3.6 – an action which can only be reset by the use of a tool (Type 1.F or 2.F);

6.4.3.7 – an action which is not intended to be reset under electrically loaded conditions (Type 1.G or 2.G);

6.4.3.8 – a trip-free mechanism in which the contacts cannot be prevented from opening and which may automatically be reset to the "closed" position after normal operation conditions have been restored if the reset means is held in the "reset" position (Type 1.H or 2.H);

6.4.3.9 – a trip-free mechanism in which the contacts cannot be prevented from opening and the control is not permitted to function as an automatic reset device if the reset means is held in the "reset" or "on" position (Type 1.J or 2.J);

6.4.3.10 – for sensing actions, no increase in the operating value as the result of a breakage in the sensing element, or in parts connecting the sensing element to the switch head (Type 1.K or 2.K);

6.4.3.11 – an action that does not require any external auxiliary energy source of electrical supply for its intended operation (Type 1.L or 2.L);

6.4.3.12 – an action which operates after a declared ageing period (Type 1.M or 2.M).

6.4.3.13 See annex H.

6.5 According to the degree of protection and control pollution situation

6.5.1 According to degrees of protection provided by enclosures against ingress of solid objects and dust (see IEC 60529).

IP0X, IP2X, IP4X, IP5X, IP6X.

6.5.2 According to degree of protection provided by enclosures against harmful ingress of water (see IEC 60529).

IPX0, IPX1, IPX3, IPX4, IPX5, IPX7.

A control intended for use in a particular environment may be used for a different environment if the appropriate provisions, if any, are made in the equipment.

Preferred combinations of degrees of protection according to 6.5.1 and 6.5.2:

First characteristic numeral **Protection against ingress of foreign bodies**	**Second characteristic numeral** **Protection against ingress of water**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	IP00							
1								
2	IP20	IP21						
3								
4		IP41		IP43	IP44			
5					IP54	IP55		
6						IP65		IP67

6.5.3 According to the pollution degree or degrees for which the control is declared. See annex N

NOTE – It is possible that when a control is mounted in accordance with the manufacturer's declaration, different parts of the control may be in macro-environments having different pollution degrees.

6.6 According to method of connection

6.6.1 Control with at least one terminal intended for the connection of fixed wiring.

In some countries flying leads are allowed.

6.6.2 Control with at least one terminal intended for the connection of a flexible cord.

A control may be classified under both 6.6.1 and 6.6.2

6.6.3 Control without any terminals intended for the connection of an external conductor.

This type of control is intended for the connection of only integrated or internal conductors.

6.7 According to ambient temperature limits of the switch head

6.7.1 Control with a switch head for use in an ambient temperature between a minimum value (T_{min}) of 0 °C, and a maximum value (T_{max}) of 55 °C.

6.7.2 Control with a switch head intended to be used in an ambient temperature having a maximum value (T_{max}) other than 55 °C but no less than 30 °C, or a minimum value (T_{min}) lower than 0 °C, or both.

Preferred values of T_{max} are 30 °C, 55 °C, 70 °C, 85 °C, 105 °C, 125 °C, 150 °C. Preferred values of T_{min} are 0 °C, -10 °C, -20 °C, -30 °C, and -40 °C.

Values differing from these preferred values are allowed.

6.8 According to protection against electric shock

6.8.1 For an integrated control:

An integrated control is not classified but takes the classification of the equipment with which it is integrated

6.8.2 For an incorporated control for use in:

6.8.2.1 – class 0 equipment;

6.8.2.2 – class 0I equipment;

6.8.2.3 – class I equipment;

6.8.2.4 – class II equipment;

6.8.2.5 – class III equipment.

For definitions of class 0, class 0I, class I, class II or class III equipment, see IEC 60536. A control intended for incorporation in a particular class of equipment may be used for a different class if appropriate provisions are made in the equipment.

6.8.3 For an in-line cord control, a freestanding control, or an independently mounted control:

6.8.3.1 – of class 0;

6.8.3.2 – of class 0I;

6.8.3.3 – of class I;

6.8.3.4 – of class II;

6.8.3.5 – of class III.

6.9 According to circuit disconnection or interruption:

6.9.1 – full-disconnection;
6.9.2 – micro-disconnection;
6.9.3 – micro-interruption;
6.9.4 – all-pole disconnection;
6.9.5 – See annex H.

Some equipment standards may require full-disconnection, others may permit either full-disconnection or micro-disconnection; some may only require micro-interruption.

Different actions of a control may provide different circuit disconnections or interruptions.

6.10 According to number of cycles of actuation (M) of each manual action

Preferred values are:

6.10.1 - 100 000 cycles;

6.10.2 - 30 000 cycles;

6.10.3 - 10 000 cycles;

6.10.4 - 6 000 cycles;

6.10.5 - 3 000 cycles [1)];

6.10.6 - 300 cycles [1)];

6.10.7 - 30 cycles [1)].

[1)] Applicable only to actions of controls for specific equipment and applications such as voltage-tap controls, summer/winter controls for water heaters and where permitted by the appropriate equipment standard.

For controls with more than one manual action, a different value may be declared for each. If a control has more than one intended "OFF" position, then a cycle of actuation shall be regarded as a movement from one "OFF" position to the next "OFF" position.

6.11 According to number of automatic cycles (A) of each automatic action

Preferred values are:

6.11.1 - 300 000 cycles;

6.11.2 - 200 000 cycles;

6.11.3 - 100 000 cycles;

6.11.4 - 30 000 cycles;

6.11.5 - 20 000 cycles;

6.11.6 - 10 000 cycles;

6.11.7 - 6 000 cycles;

6.11.8 - 3 000 cycles [1)];

6.11.9 - 1 000 cycles [1)];

6.11.10 - 300 cycles [2)] ;

6.11.11 - 30 cycles [2)4)] ;

6.11.12 - 1 cycle [3)]

[1)] Not applicable to thermostats or to other fast cycling actions.

[2)] Applicable only to manual reset.

[3)] Applicable only to actions which require the replacement of a part after each operation.

[4)] Can only be reset during manufacturer servicing.

For controls having more than one automatic action, a different value may be declared for each.

6.12 According to temperature limits of the mounting surface of the control

6.12.1 Control suitable for mounting on a surface which is not more than 20 K above the ambient temperature classified in 6.7.

6.12.2 Control suitable for mounting on a surface which is more than 20 K above the ambient temperature classified in 6.7.

An example of such a control is one mounted on a compressor unit in a refrigerator, where the mounting surface may be 150 °C, although the sensing element is at a temperature of −10 °C, and the ambient temperature is only 30 °C.

6.13 According to value of proof tracking index (PTI) for the insulation material used

6.13.1 – material of material group IIIb with a PTI of 100 and up to but excluding 175;

6.13.2 – material of material group IIIa with a PTI of 175 and up to but excluding 400;

6.13.3 – material of material group II with a PTI of 400 and up to but excluding 600;

6.13.4 – material of material group I with a PTI of 600 and over.

6.14 According to period of electrical stress across insulating parts supporting live parts and between live parts and earthed metal

6.14.1 – short period;

6.14.2 – long period.

Long periods of electrical stress are considered to exist if the control is used in an equipment for continuous use, and also for the supply side of a control in any other equipment unlikely to be disconnected from the supply by the removal of a plug or by the operation of a control providing full disconnection.

6.15 According to construction:

6.15.1 – integrated control;

6.15.2 – incorporated control;

6.15.3 – in-line cord control;

6.15.3.1 – free-standing control;

6.15.4 – independently mounted control for:

6.15.4.1 – surface mounting;

6.15.4.2 – flush mounting;

6.15.4.3 – panel mounting.

6.15.5 See annex J.

6.16 According to ageing requirements (Y) of the equipment in which, or with which, the control is intended to be used

6.16.1 – 60 000 h;

6.16.2 – 30 000 h;

6.16.3 – 10 000 h;

6.16.4 – 3 000 h;

6.16.5 – 300 h;

6.16.6 – 15 h.

Controls which operate during the heating or endurance tests of the equipment standard are not classified according to this subclause.

6.17 According to use of the thermistor

See annex J.

6.18 According to software class

See annex H.

7 Information

7.1 General requirements

The control manufacturer shall provide adequate information to confirm:

- that a suitable control can be selected;
- that the control can be mounted and used in a manner that will enable it to meet the requirements of this standard; and
- that the relevant tests can be performed to determine compliance with this standard.

7.2 Methods of providing information

7.2.1 Information shall be provided using one or more of the following methods. The information required for controls and the appropriate method for providing this information shall be as indicated in table 7.2.

It is not intended that table 7.2 itself necessarily be the actual form used to communicate between manufacturer and test house.

- By marking (C) – this information shall be provided by marking on the control itself, except that, in the case of an integrated control, such marking can be on an adjacent part of the equipment, provided that it is clear that it refers to the control.

  Information provided by marking (C) may also be included in documentation (D).

- By documentation (D) – this information shall be provided for the user or installer of the control, and shall consist of legible instructions. Each control shall be accompanied by such instructions. Instruction sheets and other texts required by this standard shall be written in the official language(s) of the country in which the control is to be sold.

For controls intended to be exclusively delivered to the equipment manufacturer, the instruction sheet may be replaced by a leaflet, letter or drawing, etc. It is not necessary for each control to be accompanied by such a document.

- By declaration (X) – this information shall be provided for the testing authority for purposes of test and in a manner agreed between testing authority and manufacturer. It may, for example, be provided by a marking on the control, by a leaflet, letter or drawing or, in the case of a control submitted in, on or with an equipment, by measurement or inspection of the submitted equipment.

Information which is indicated as being required by declaration (X) should also be provided to the equipment manufacturer, as appropriate.

7.2.2 Information which is indicated as being required by marking (C) or by documentation (D) shall also be provided for the testing authority in an agreed manner if so requested by the testing authority.

7.2.3 For controls submitted in, on or with an equipment, the requirement for documentation (D) is replaced by declaration (X).

7.2.4 For an integrated control forming part of a more complex control, the marking relating to the integrated control may be included in the marking of the more complex control.

7.2.5 The requirement for documentation (D) is considered to be met if such information has been provided by marking (C).

7.2.5.1 The requirement for declaration (X) is considered to be met if such information has been provided by either documentation (D) or by marking (C).

7.2.6 Except as indicated in 7.4, for integrated controls all information is provided by means of declaration (X). Unless otherwise indicated in a part 2, for incorporated controls, the only marking required is the manufacturer's name or trade mark and the unique type reference, if other required marking is provided by documentation (D). For incorporated controls declared under item 50, see the explanation of documentation (D) contained in 7.2.1.

7.2.7 For controls that are neither integrated nor incorporated, where lack of space prevents legible marking as specified, the control shall be marked with the manufacturer's name (or trade mark) and the unique type reference only. The other marking required shall be included in documentation (D).

7.2.8 Additional marking or information is allowed, provided that it does not give rise to misunderstanding.

7.2.9 When symbols are used, they shall be as follows:

Amperes	A
Volts	V
Watts	W
Volts-amperes	VA
Alternating current (single-phase)	~
Alternating current (three-phase)	3~
Alternating current (three-phase with neutral)	3N~
Direct current	⎓

Class II construction .... ⧈

Ambient temperature limits of switch head ....T (The letter T preceded by a minus sign and the numerical value of the lower temperature if T_{min} less than 0 °C, or followed by the numerical value of the higher temperature if T_{max} other than 55 °C.)

Rated current of the appropriate fuse in amperes........................ ⏛ A

Frequency .... Hz

Earthing terminal .... ⏚

For identification of the degree of protection provided by enclosures, the symbols shown in 6.5 shall be used.

Information about rated current and rated voltage may be provided by using figures alone, the figure for the rated current preceding or above that for the rated voltage and separated from it by a line. For circuits for resistive load and inductive loads, the rated current for inductive load is placed between parentheses and immediately following the rated current for resistive load. The symbol for the nature of the supply is placed after the current and voltage.

Current, voltage and nature of supply may be indicated as follows:

$$16\ (3)\ \text{A}\ 250\ \text{V} \sim \quad \text{or} \quad 16\ (3)\ /\ 250 \sim \quad \text{or} \quad \frac{16\ (3)}{250} \sim$$

The following are examples of ways to provide information about the temperature limits of a control:

- 20T 30 (meaning minus 20 °C up to plus 30 °C)

T85 (meaning 0 °C up to plus 85 °C)

Information concerning declared specific loads may be given by reference to drawings or to types, for example: "Electric motor, drawing No. ..., part list No. ..., made by..." or "5 x 80 W fluorescent".

Table 7.2

Information	Clause or subclause	Method
1 Manufacturer's name or trade mark 2)	7.2.6	C
2 Unique type reference 1)2)	2.11.1, 2.13.1, 7.2.6	C
3 Rated voltage or rated voltage range in volts (V)	4.3.2, 2.1.2	C
4 Nature of supply unless the control is for both a.c. and d.c., or unless the rating is the same for a.c. and d.c.	4.3.2, 6.1	C
5 Frequency if other than for range 50 Hz to 60 Hz inclusive	4.3.2	C
6 Purpose of control	2.2, 4.2.4, 4.3.5, 6.3, 17.16	D
6a Construction of control and whether the control is electronic	6.15, annex H, H.2.5.7	D
7 The type of load controlled by each circuit 7)	6.2, 14, 17, 23.1.1	C
15 Degree of protection provided by enclosure 8)	6.5.1, 6.5.2 11.5	C
17 Which of the terminals are suitable for the connection of external conductors, and if they are suitable for line or neutral conductors, or both	6.6, 7.4.2 7.4.3	C
18 Which of the terminals for external conductors are for a wider range of conductor sizes than those indicated in the table of 10.1.4.	10.1	D

Table 7.2 *(continued)*

Information	Clause or subclause	Method
19 For screwless terminals the method of connection and disconnection [9)]	10	D
20 Details of any special conductors which are intended to be connected to the terminals for internal conductors	10.2	D
21 Maximum temperature of terminals for internal conductors, if higher than 85 °C	14	X
22 Temperature limits of the switch head, if T_{min} lower than 0 °C or T_{max} other than 55 °C	6.7, 14.5 14.7, 17.3	C
23 Temperature limits of mounting surfaces (T_s)	6.12.2, 14.1, 17.3	C
24 Classification of control according to protection against electric shock	6.8	X
25 For Class II controls, the symbol for Class II construction	7.3	C
26 Number of cycles of actuation (M) for each manual action	6.10, 17.10, 17.11	X
27 Number of automatic cycles (A) for each automatic action	6.11, 17.8, 17.9	X
28 Ageing period (Y) for controls with Type 1M or 2M action	6.16, 17.6	X
29 Type of disconnection or interruption provided by each circuit	2.4.1, 2.4.2, 2.4.3, 2.4.4, 6.9	X
30 PTI of materials used for insulation	6.13, table 20.3, note 2	X
31 Method of mounting control [5)]	11.6	D
31a Method of providing earthing of control	7.4.3, 9, 9.1.1, 9.1.2	D
32 Method of attachment for non-detachable cords [6)]	10.1, 11.7	D
33 Intended transportation condition of control [20)]	16.1	X
34 Details of any limitation of operating time [21)]	14, 17	D
35 Period of electric stress across insulating parts	6.14	X
36 Limits of activating quantity for any sensing element over which micro-disconnection is secure (see also H.7.2, item 36)	11.3.2	X
37 Minimum and/or maximum rates of change of actuating quantity, or minimum and/or maximum cycling rates for a sensing control [4)]	4.1.7, 15, 17	X
38 Values of overshoot of activating quantity for sensing controls which are necessary for correct action, or which can be used for test purposes	17	X
39 Type 1 or Type 2 action	6.4	D
40 Additional features of Type 1 or Type 2 actions	6.4.3, 11.4	D
41 Manufacturing deviation and condition of test appropriate to deviation	2.11.1, 11.4.3, 15 17.14	X
42 Drift	2.11.2, 11.4.3, 15, 16.2.4	X
43 Reset characteristics for cut-out action [3)]	6.4	D
44 If a control is either to be hand-held or is intended for a hand-held equipment	21	X
45 Any limitation to the number or distribution of flat push-on receptacles which can be fitted	10.2.4.4	D
46 Operating sequence for controls with more than one circuit, if significant	11.4.3	D

Table 7.2 *(continued)*

Information	Clause or subclause	Method
47 Extent of any sensing element	2.8.1	D
48 Operating value (or values) or operating time	2.3.11, 2.3.12, 6.4.3.10, 11, 14, 15.6,17	D
49 Control pollution situation	6.5.3	D
50 Control intended to be delivered exclusively to the equipment manufacturer	7.2.1, 7.2.6	X
51 Heat and fire resistance category	21	X
52 to 60 See annex H		
61 to 65 See annex J 10) 11)		
66 to 74 See annex H		
75 Rated impulse voltage	2.1.12, 20.1	D
76 Type of printed circuit board coating	Annex P or Annex Q	X
77 Temperature for the ball pressure test	21.2.5	D

Items 8 to 14, inclusive, are void

NOTES

1) The unique type reference shall be such that, when it is quoted in full, the manufacturer of the control can supply a replacement which will be fully interchangeable with the original electrically, mechanically, dimensionally, and functionally.

It may comprise a series type reference with other marking, such as voltage rating or an ambient temperature marking, which together provide a unique type reference.

2) Void

3) The manufacturer may declare a time before which, or a specific value of activating quantity above which, manual reset shall not occur.

4) α_1 = minimum rising rate

β_1 = minimum falling rate

The rate of change (α_1 and β_1) of the activating quantity are those applicable to normal use.

α_1 = maximum rising rate (for Type 2 actions only)

β_1 = maximum falling rate (for Type 2 actions only)

For test purposes, α_1 and β_1 shall be as declared but not lower than the limit(s) indicated in the appropriate Part 2s for Type 1 actions and/or Type 2 actions. The values α_1 and β_1 are for test purposes only, and may alternatively be declared as a maximum cycling rate. The rates of change for the purpose of this standard shall be expressed in the units as shown in the following table*:

Activating quantity	*Unit for rate of change
Pressure	Pa/s
Temperature	K/h
Position	mm/s
Illumination	lux/s
Velocity	mm/s^2
Liquid level	mm/s
Current	A/s
Humidity	% HR/s
Air flow	m^3/s^2

* When using other activating quantities, the units should be expressed as SI units.

Table 7.2 *(concluded)*

5) If, for independently mounted controls, it is necessary to take special precautions when installing or using the control, these details shall be given in an instruction sheet accompanying the control.

Special precautions may be necessary, for example, for flush mounting independently mounted controls. In order to ensure that, after building-in, the conditions necessary to meet the requirements of this standard are achieved, the instruction sheet for such controls shall include clear information concerning:

- the dimensions of the space to be provided for the control;
- the dimensions and position of the means for supporting and fixing the control within this space;
- a minimum clearance between the various parts of the control and the surrounding parts of the fitment;
- the minimum dimensions of ventilating openings and their correct arrangements;
- the connection of the control to the supply and the interconnection of separate components, if any.

If the supply conductors of a control can come into contact with parts of a terminal block or a compartment for fixed wiring, and these parts have, under conditions of normal use, a temperature exceeding that specified in table 14.1, the instruction sheet shall also state that the control shall be connected by means of conductors having the appropriate T rating (see note 1 of table 14.1).

6) In-line cord, free-standing and independently mounted controls, if fitted with non-detachable cords using attachment methods Y or Z, shall have Documentation (D) containing the substance of one of the following statements, whichever is appropriate:

- "The supply cord of this control cannot be replaced; if the cord is damaged, the control should be discarded" (Z)

or

- "The supply cord of this control can be replaced only by the manufacturer or his accredited service agent" (Y).

7) For controls with more than one circuit, the current applicable to each circuit and to each terminal. If these are different from each other, then it shall be made clear to which circuit or terminal the information applies. For circuits for resistive and inductive loads, the rated current, or the rated load in VA, at power factors as indicated in the appropriate table of 17.2.

8) The marking (C) requirement does not apply to controls or parts thereof classified as IP00, IP10, IP20, IP30 and IP40.

9) In Canada and the United States, marking (C) is required for the method of connection and disconnection of screwless terminals for field wiring.

10) See annex J.

11) See annex J.

12) to 19) See annex H.

20) The method of packaging does not have to be declared.

21) For in-line cord, free-standing and independently mounted controls, this information shall be provided by method C.

7.3 Class II symbol

7.3.1 The symbol for class II construction shall be used only for controls classified according to 6.8.3.4.

7.3.2 The dimension of the symbol for class II construction shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square.

7.3.2.1 The length of the sides of the outer square of the symbol shall be not less than 5 mm, unless the largest dimension of the control is 15 mm in length or less, in which case the dimension of the symbol may be reduced but the length of the sides of its outer square shall be not less than 3 mm.

7.4 Additional requirements for marking

7.4.1 Required marking on a control shall preferably be on the main body of the control but may be placed on non-detachable parts.

Required markings shall be legible and durable.

Compliance is checked by inspection and by the tests of annex A.

7.4.2 Terminals of controls intended for the connection of supply conductors shall be indicated by an arrow pointing towards the terminal, unless the method of connection to the supply mains is of no importance or is self-evident.

Compliance is checked by inspection.

7.4.3 Terminals intended exclusively for a neutral external conductor shall be indicated by the letter "N".

7.4.3.1 Earthing terminals for external earthing conductors, and terminals for earthing continuity of class II and class III controls, shall be indicated by the earth symbol.

7.4.3.2 All other terminals shall be suitably identified, their purpose self-evident or the control circuitry visually apparent. The arrow, the letter "N" or the earth symbol shall not be used except as indicated above.

Compliance is checked by inspection.

In the United States, a terminal intended for connection of a grounded supply conductor shall be finished to show a white or natural grey colour and shall be distinguishable from the other parts.

In the United States, a wire-binding screw intended for the connection of an equipment earthing conductor shall have a slotted or hexagonal green-coloured head. A pressure wire connector intended for connection of such a conductor shall be identified by being marked GROUND, GROUNDING, EARTH or by a marking on a wiring diagram provided on the control. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during servicing of the control.

With respect to 7.4.2 to 7.4.3.2 inclusive, in some countries, additional or alternative markings are required in the wiring rules.

7.4.4 Controls intended to be set by the user or by the equipment manufacturer during installation shall be provided with an indication of the direction to increase or decrease the response value.

An indication of "+" or "–" is sufficient.

Controls intended to be set by the equipment manufacturer or the installer shall be accompanied by documentation (D) indicating the proper method for securing the setting.

7.4.5 Parts destroyed during the normal operation of the control and which have to be replaced, shall be marked so as to enable them to be identified from a catalogue or the like, even after they have operated, unless they are intended to be replaced only during manufacturer servicing.

8 Protection against electric shock

8.1 General requirements

8.1.1 Controls shall be so constructed that there is adequate protection against accidental contact with live parts, in any unfavourable position which may occur in normal use, and after any accessible detachable parts, other than lamps located behind a detachable cover have been removed. However, during the insertion and removal of lamps, protection against accidental contact with live parts of the lamp cap shall be ensured.

Unless otherwise specified, parts connected to a safety extra-low voltage supply not exceeding 24 V are not considered to be hazardous live parts.

In some countries, parts connected to a safety extra-low voltage supply not exceeding 30 V are not considered to be hazardous live parts.

8.1.2 For class II controls and controls for class II equipment, this requirement applies also with regard to accidental contact with metal parts separated from hazardous live parts by basic insulation only.

8.1.3 The insulating properties of lacquer, enamel, paper, cotton, oxide film on metal parts, beads and sealing compounds shall not be relied upon to give the required protection against accidental contact with hazardous live parts.

Sealing compounds of the self-hardening types may be touched.

8.1.4 For those class II controls and controls for class II equipment which are connected in normal use to the gas supply mains or to the water supply mains, any metal parts conductively connected to the gas pipes or in electrical contact with the water system shall be separated from hazardous live parts by double insulation or reinforced insulation.

8.1.5 Those class II controls and controls for class II equipment which are intended to be permanently connected to fixed wiring shall be so designed that the required degree of protection against electric shock is not impaired by the installation of the control.

The protection against electric shock of class II independently mounted controls may be affected, for example, by the installation of metal conduits or of cables provided with a metal sheath.

8.1.6 *For integrated and incorporated controls the tests of 8.1.9 to 8.1.9.5 inclusive is only applied to those parts of the control which are accessible when it is mounted in any position in accordance with the manufacturer's declarations and after removal of detachable parts.*

8.1.7 *For in-line cord and free-standing controls the tests of 8.1.9 to 8.1.9.5 inclusive, are made when the control is fitted with flexible cords either of the smallest, or of the largest nominal cross-sectional area used in 10.1.4, whichever is more unfavourable. Detachable parts are removed, and hinged covers which can be opened without the use of a tool are opened.*

8.1.8 *For independently mounted controls the test is made when the control is mounted as in normal use, fitted with cable of the smallest or of the largest nominal cross-sectional area used in 10.1.4, whichever is more unfavourable, or with a rigid, pliable or flexible conduit. Detachable parts are removed, and hinged covers which can be opened with the use of a tool are opened.*

8.1.9 *Compliance with 8.1.1 to 8.1.8 inclusive is checked by inspection and by the following tests:*

The standard test finger shown in figure 2 is applied without force in every possible position. Apertures preventing the entry of the finger are further tested by means of a straight unjointed test finger of the same dimensions which is applied with a force of 20 N; if this finger enters, the test with the finger shown in figure 2 is repeated, the finger being pushed through the aperture if necessary. If the unjointed test finger does not enter, the force applied is increased to 30 N. If then the guard is so displaced or the aperture so distorted that the test finger shown in figure 2 can be inserted without force, the test with the latter finger is repeated. An electrical contact indicator is used to show contact.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

8.1.9.1 *The standard test finger shall be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger in the same direction only.*

8.1.9.2 *In addition, openings in insulating material and in unearthed metal shall be tested by applying the test pin shown in figure 1 without force in every possible position.*

8.1.9.3 *It shall not be possible, with either the standard test finger or the test pin, to touch hazardous live parts.*

8.1.9.4 *For controls which have any parts of double insulation construction, it shall not be possible to touch metal parts with the standard test finger which are only separated from hazardous live parts by basic insulation.*

8.1.9.5 *If there is an instruction to remove a part during normal use or user maintenance and if there is no warning on the part which indicates: "Disconnect from supply before removing", that part is regarded as a detachable part even if a tool has to be used for its removal. If there is such a warning on the part, it is permissible, after removal, to touch parts separated from hazardous live parts by basic insulation.*

8.1.10 See annex H.

8.1.11 Between class III circuits and circuits connected to the mains or earth, insulation external to the safety isolating transformer shall comply with all requirements for class II insulation.

Where a circuit is not specifically required to be class III, class II requirements may not be applicable between the class III circuit and earth.

8.1.12 A live part shall be considered to be hazardous if it is intended to be at some time connected to a source of voltage other than safety extra-low voltage and it is not separated from the source by protective impedance complying with H.8.1.10 and is not a PEN conductor.

8.2 Actuating members and actuating means

8.2.1 An actuating member shall not be live.

8.2.2 An actuating means shall not be live, unless either it is provided with an insulated actuating member which is adequately fixed or the actuating means is not accessible when the actuating member is removed.

Compliance with 8.2.1 and 8.2.2 is checked by inspection and by the tests of 8.1.

An insulated actuating member shall be considered to be adequately fixed if it can be removed only by breaking, cutting, or after being seriously damaged.

8.2.3 For controls other than class III or controls for equipment other than those of class III, actuating members and handles held in normal use shall be either of insulating material, or adequately covered by insulating material; or, if of metal, their accessible parts shall be separated from their actuating means, or fixings by supplementary insulation, if such would be likely to become live in the event of an insulation fault.

For controls for connection to fixed wiring, or for controls for stationary equipment this requirement does not apply provided that such parts are either:

- reliably connected to an earthing terminal or earthing contact; or
- shielded from hazardous live parts by earthed metal.

Compliance is checked by inspection.

Parts separated from hazardous live parts by double insulation or reinforced insulation are not regarded as likely to become live in the event of an insulation fault.

8.3 Capacitors

8.3.1 For class II in-line cord controls and independently mounted controls, capacitors shall not be connected to accessible metal parts. For controls for class II equipment, capacitors shall not be connected to metal likely to be connected to accessible metal when the control is mounted in accordance with the manufacturers' declarations. Metal casings of capacitors shall be separated by supplementary insulation from accessible metal parts, and from other metal parts likely to be connected to accessible metal, when the control is mounted in accordance with the manufacturers' declarations.

Compliance is checked by inspection and by the requirements for supplementary insulation in clauses 13 and 20.

8.3.2 Controls intended to be connected to the supply by means of a plug shall be so designed that in normal use there is no risk of electric shock from charged capacitors when touching the pins of the plug.

Compliance is checked by the test of 8.3.2.1 to 8.3.2.4 inclusive, which is made 10 times.

8.3.2.1 *The control is supplied at rated voltage or at the upper limit of the rated voltage range.*

8.3.2.2 *The actuating member, if any, is then moved to the "OFF" position if one exists and the control is disconnected from the supply by removing the plug from the socket-outlet.*

8.3.2.3 *One second after disconnection, the voltage between the pins of the plug is measured.*

8.3.2.4 *The voltage shall not exceed 34 V. The test is only performed if the capacitor exceeds 0,1 μF.*

8.4 Covers and uninsulated live or hazardous parts

Controls provided with a cover or cover plate of non-metallic material shall be so designed that the cover fixing screws are not accessible, unless they are either earthed or separated from hazardous live parts by double insulation or reinforced insulation or not accessible after mounting in the equipment.

Compliance is checked by inspection.

In some countries, hazardous live parts are required to be so arranged, and the cover so located, that persons are not likely to be exposed to shock hazard while removing and replacing the cover.

In some countries, hazardous live parts or hazardous moving parts are required to be so located, guarded or enclosed so as to reduce the likelihood of contact of such parts by persons while changing lamps, electron tubes or fuses; lubricating parts; or during other operations carried out during user maintenance or servicing.

9 Provision for protective earthing

9.1 General requirements

9.1.1 Accessible metal parts, other than actuating members, of in-line cord, free-standing and independently mounted controls of class 0I and class I which may become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal or termination within the control, or to the earthing contact of an equipment inlet.

The phrase "permanently and reliably connected to an earthing terminal" is synonymous with the term "bonded".

Parts separated from live parts by double insulation or reinforced insulation and parts screened from live parts by metal parts connected to an earthing terminal, earthing termination or earthing contact, are not regarded as likely to become live in the event of an insulation fault.

Requirements for actuating members are specified in 8.2.3.

9.1.2 Accessible metal parts, other than actuating members, of integrated and incorporated controls for class 0I and class I equipment which may become live in the event of an insulation fault shall have provision for earthing.

Integrated controls and incorporated controls may be connected to earth through their fixing means, provided that provision is made for clean metallic surfaces. This also applies, for example, to controls with metallic sensing elements which are connected reliably to the metal parts of the equipment if the manufacturer has declared this to be a method of earthing.

Parts separated from live parts by double insulation or reinforced insulation, and parts screened from live parts by metal parts connected to an earthing terminal, earthing termination or earthing contact, are not regarded as likely to become live in the event of an insulation fault.

Requirements for actuating members are specified in 8.2.3.

9.1.3 Earthing terminals, earthing terminations and earthing contacts shall not be electrically connected to any neutral terminal.

Compliance with 9.1.1 to 9.1.3 inclusive is checked by inspection.

9.2 Class II and class III controls shall have no provision for protective earthing.

Compliance is checked by inspection.

When it is necessary to interconnect earthed parts of an equipment or system through a situation which itself is either of class II or class III construction, such interconnection, including terminals or terminations, is permitted in the class II or class III situation, if all parts of the earthing circuit are separated from live parts or accessible surfaces by double or reinforced insulation.

9.3 Adequacy of earth connections

9.3.1 General requirements

The connection between an earthing terminal, earthing termination or earthing contact, and parts required to be connected thereto, shall be of low resistance.

Compliance is checked by the following test:

- *A current of 1,5 times the rated current, but not less than 25 A, and derived from an a.c. source with a no-load voltage not exceeding 12 V, is passed between the earthing terminal, earthing termination or earthing contact, and each of the parts, in turn.*
- *The voltage drop between the earthing terminal, earthing termination or earthing contact and the part is measured, and the resistance calculated from the current and this voltage drop. In no case shall the resistance exceed 0,1 Ω. The test is continued until steady conditions have been established.*

Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

The resistance of any external conductor or internal conductor is not included in the resistance measurement, but the resistance of any integrated conductor is included.

9.3.2 Fixed wiring and methods X and M

Earthing terminals for the connection of fixed wiring or for non-detachable cords using methods X and M shall comply with the requirements of 10.1.

In Canada and the USA, a quick connect terminal having the dimensions indicated in table 9.3.2 may be employed as a non-accessible earthing terminal provided it has additional means for preventing displacement in use and it is used on a circuit having a protective device as specified in the table.

In some countries, an earthing conductor in fixed wiring or in a supply cord shall not be terminated by means of a quick-connect terminal.

Table 9.3.2

Nominal sizes mm			Rating of circuit protective device A
Width	Thickness	Length	
4,8	0,5	6,4	20 or less
4,8	0,8	6,4	20 or less
5,2	0,8	6,4	20 or less
6,3	0,8	8,0	60 or less

9.3.3 External conductors

Earthing connections for external conductors shall not be made using screwless terminals.

The use of screwless terminals for the connection of external earthing conductors is under consideration.

9.3.4 Size of accessible earthing terminals

Earthing terminals which are accessible in normal use shall allow the connection of conductors having nominal cross-sectional areas of 2,5 mm^2 to 6 mm^2 inclusive and it shall not be possible to loosen them without the aid of a tool.

In Canada and the USA, conductors of other nominal cross-sectional area are permitted.

9.3.5 Size of non-accessible earthing terminals

Earthing terminals which are not accessible in normal use for external conductors shall be of a size equal to or larger than that required for the corresponding current-carrying terminal.

9.3.6 Locking of earthing terminals

Clamping means of earthing terminals for external conductors shall be adequately locked against accidental loosening.

Compliance with 9.3.2 to 9.3.6 inclusive is checked by inspection, by manual test and by the appropriate tests of 10.1.

In general, the designs commonly used for current-carrying terminals provide sufficient resilience to comply with the requirement for adequate locking against accidental loosening, provided that there is no excessive vibration or temperature cycling. If the terminal is subjected to excessive vibration or temperature cycling, special provision such as the use of an adequately resilient part, for example, a pressure plate which is not likely to be removed inadvertently, may be necessary when pillar terminals are used.

9.4 Corrosion resistance

All parts of an earthing terminal shall be resistant to corrosion resulting from contact between those parts and the copper of the earthing conductor or any other metal that is in contact with those parts.

9.4.1 Materials

The body of an earthing terminal shall be of brass, or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure. Then any screws or nuts shall be of brass, plated steel or other metal complying with clause 22, or other metal no less resistant to corrosion.

9.4.2 Frames or enclosures of aluminum

If the body of an earthing terminal is a part of a frame or enclosure of aluminum or aluminum alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminum or its alloys.

Compliance with 9.4, 9.4.1, and 9.4.2 is checked by inspection, and in cases of doubt by an analysis of the materials and their coatings.

Corrosion resistance may be achieved by plating or similar process.

9.5 Other requirements

9.5.1 Detachable parts

If a detachable part of a control has an earth connection, this connection shall be made before any current-carrying connections are established when placing the part in position, and any current-carrying connections shall be separated before the earth connection is broken when removing the part.

Compliance is checked by inspection.

In some countries 9.5.1 does not apply.

9.5.2 Incorporated control

If an incorporated control is likely to be separated from its normal earthing means after mounting in the equipment for purposes of testing, setting or servicing while the equipment is energized, it shall be provided with an earthing connection or with an earthing conductor which does not require removal from the control for such testing, setting or servicing.

Compliance is checked by inspection.

Refrigerator temperature sensing controls and defrost controls are examples.

In some countries 9.5.2 does not apply.

10 Terminals and terminations

See also clause 20, third paragraph.

10.1 Terminals and terminations for external copper conductors

10.1.1 Terminals for fixed wiring and for non-detachable cords using attachment methods X and M, except as specified in 10.1.3, shall be such that connection is made by means of screws, nuts or equally effective devices or methods, but without requiring a special purpose tool for connection or disconnection.

10.1.1.1 Terminals or terminations for non-detachable cords using attachment methods Y and Z shall satisfy the appropriate requirements for terminals and terminations for internal conductors and may require the use of special purpose tools for connection or disconnection.

Compliance with 10.1.1 and 10.1.1.1 is checked by inspection and test.

Screwless terminals are deemed to be equally effective devices. Requirements are given in IEC 60998-2-2.

Flat push-on terminals are deemed to require a special purpose tool for effecting the crimp.

10.1.2 Screws and nuts which clamp external conductors shall have a metric ISO thread or a thread of equivalent effectiveness. They shall not serve to fix any other component, except that they may also clamp internal conductors if these are so arranged that they are unlikely to be displaced when fitting the external conductors.

Compliance is checked by inspection.

Provisionally, SI, BA and Unified threads are deemed to be of equal effectiveness to metric ISO thread.

A test for equivalent effectiveness is under consideration. Pending agreement to such a test, all torque values for threads other than ISO, SI, BA and Unified shall be increased by 20 %.

10.1.1 Soldered, welded, crimped or similar terminations

Soldered, welded, crimped or similar terminations shall not be used for the connection of non-detachable cords using attachment methods X and M unless such is permitted by the appropriate equipment standard. When such terminations are used for external conductors, they shall also comply with the requirements of 10.2.2 and 10.2.3.

Compliance is checked by inspection.

In general, the standards for equipment restrict the use of such connections.

10.1.4 Terminals for fixed wiring or non-detachable cords using attachment methods X or M shall allow at least the connection of conductors having nominal cross-sectional areas as shown in table 10.1.4.

Compliance is checked by inspection, by measurement and by fitting conductors of the smallest and largest cross-sectional areas specified or declared.

Table 10.1.4

Current carried by terminal A	Nominal cross-sectional area [1] mm²	
	Flexible cord conductor	Fixed wiring conductors
Up to 6 and including [2]	0,5 to 1	1 to 1,5
over 6 up to and including 10	0,75 to 1,5	1 to 2,5
over 10 up to and including 16	1 to 2,5	1,5 to 4
over 16 up to and including 25	1,5 to 4	2,5 to 6
over 25 up to and including 32	2,5 to 6	4 to 10
over 32 up to and including 40	4 to 10	6 to 16
over 40 up to and including 63	6 to 16	10 to 25

[1] In some countries other sizes of conductors apply.

[2] The nominal cross-sectional areas specified do not apply to terminals in safety extra-low voltage circuits carrying a current not exceeding 3 A.

10.1.4.1 If a terminal is designed to accommodate a wider range of fixed wiring or flexible cord conductor sizes than those indicated in columns 2 and 3 of table 10.1.4, then this shall be declared.

10.1.4.2 In the USA, creepage distances and clearances between terminals declared for external conductors for fixed wiring and between such terminals, other than earthing terminals, and adjacent metal parts shall meet the requirements of clause 20, and in addition, when measured in accordance with 10.1.4.3 shall be at least:

- 6,4 mm for rated voltages not exceeding 250 V;
- 8,0 mm for rated voltages exceeding 250 V and up to 400 V;
- 9,6 mm for rated voltages exceeding 400 V.

10.1.4.3 In the USA, the measurements of creepage and clearance distances at terminals are made twice, once with conductors of the largest cross-sectional area to be used and once without conductors fitted.

10.1.5 Terminals for fixed wiring or non-detachable cords using attachment methods X or M shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, internal conductors are not subjected to stress, and creepage distances and clearances are not reduced below the values specified in clause 20.

10.1.5.1 *Compliance is checked by inspection and by measurement after fastening and loosening a conductor of the largest cross-sectional area used in 10.1.4 10 times, the conductor being moved each time it is loosened. For threaded parts, the full torque applied is either that shown in the table of 19.1, or the torque specified in the relevant figure (see figures 10 to 13), whichever is greater.*

During the test, terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers, stirrups or other parts, that will impair the further use of the terminal.

This requirement does not imply that the terminal must be so designed that rotation or displacement is prevented, provided that its movement does not bring about non-compliance with the other requirements of this standard.

Terminals may be prevented from working loose by fixing with two screws, by fixing with one screw in a recess or by other suitable means.

Covering with sealing compound, or with resins, is only considered to be a sufficient means for preventing a terminal from working loose if:

- the seal is not subject to mechanical strain as a result of connection or disconnection of the conductor or use of the equipment; and
- the effectiveness of the sealing compound is not impaired by the temperature which is attained by the terminal under the most unfavourable conditions required by this standard.

10.1.6 Terminals for fixed wiring or non-detachable cords using attachment methods X or M shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without undue damage to the conductor, except that for screwless terminals intended for circuits carrying a current not exceeding 2 A, one of the surfaces may be of non-metallic material.

Compliance is checked by inspection of the terminal and of the conductors after the test of 10.1.5.

Conductors are considered to be unduly damaged if they show sharp or deep indentations.

10.1.7 Terminals for fixed wiring and non-detachable cords using attachment method X shall not require special preparation of the conductor in order to effect correct connection.

10.1.7.1 Terminals for attachment method X may also have alternative means of connection if at least one of the means conforms to this requirement, even if the original factory-made connection uses another means. In this case the original factory-made connection shall comply with the requirements for terminals and terminations for internal conductors.

Compliance is checked by inspection.

The term "special preparation of the conductor" covers soldering of the strands, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate its end.

10.1.8 Terminals for fixed wiring and non-detachable cords using attachment methods X or M shall be so designed or placed that neither the conductor nor a wire of a stranded conductor can slip out while any clamping screws or nuts are being tightened, or while any equally effective device is being operated.

10.1.8.1 *Compliance is checked by the following test.*

10.1.8.2 *Terminals are fitted with conductors according to the use of the terminal, in accordance with table 10.1.8. The wires of fixed wiring conductors are straightened before inserting into the terminal.*

10.1.8.3 *The wires of flexible cables and cords are twisted so that there is an even twist of one complete turn in 20 mm. The conductor is inserted into the terminal for the minimum distance prescribed, or where no distance is prescribed, until it just projects from the far side of the terminal. The conductor is inserted into the terminal in the position most likely to assist a wire to escape and then the screw is tightened with a torque equal to two-thirds of the torque specified in the table of 19.1.*

10.1.8.4 *For flexible cords the test is repeated using a new conductor which is twisted as before, but in the opposite direction. After the test no wire of the conductor shall have escaped into the gap between the clamping means and the retaining device.*

Table 10.1.8

Current carried by terminal A		Conductor to be fitted (number of wires and nominal diameter of each wire in millimetres)	
Flexible cord conductors	**Fixed wiring conductors**	**For flexible cord conductors**	**For fixed wiring conductors**
0 – 6	–	32 × 0,20	–
6 – 10	0 – 6	40 × 0,25	7 × 0,52
10 – 16	6 – 10	50 × 0,25	7 × 0,67
16 – 25	10 – 16	56 × 0,30	7 × 0,85
25 – 32	16 – 25	84 × 0,30	7 × 1,04
–	25 – 32	94 × 0,30	7 × 1,35
32 – 40	32 – 40	80 × 0,40	7 × 1,70
40 – 63	40 – 63	126 × 0,40	7 × 2,14

10.1.9 Terminals shall be so designed that they clamp the conductor reliably.

Compliance is checked by the following test.

10.1.9.1 *The terminals are fitted with conductors of the smallest and largest nominal cross-sectional areas used in 10.1.4, fixed or flexible, whichever is appropriate, or the more unfavorable and the terminal screws are tightened, the torque applied being equal to two-thirds of the torque specified in the table of 19.1. Each conductor is subjected to a pull of the value shown in table 10.1.9. The pull is applied without jerks for 1 min, in the direction of the axis of the conductor space.*

10.1.9.2 *This pull test is normally applied directly to the conductor adjacent to where it enters the terminal. If, however, an additional crimping or clamping device holding the conductor or the insulation around the conductor exists not more than 30 mm from the entry point for the conductor into the terminal and measured along the length of the conductor, this test should apply to the crimping or clamping device, and not to the actual terminal.*

10.1.9.3 During the test the conductor shall not move appreciably in the terminal.

Table 10.1.9

Current carried by terminal A	Pull N	
	Terminals for flexible cord conductors	**Terminals for fixed wiring conductors**
Up to and including 3	20 [1]	20 [1]
over 3 up to and including 6	30	30
over 6 up to and including 10	30	50
over 10 up to and including 16	50	50
over 16 up to and including 25	50	60
over 25 up to and including 32	60	80
over 32 up to and including 40	90	90
over 40 up to and including 63	100	100

[1] Applicable only to safety extra-low voltage circuits, and other applications where particular conductors are not specified.

10.1.10 Terminals shall be so designed that they do not attain excessive temperature in normal use, so as to damage the material of the supporting insulation, or the insulating covering of the clamped conductors.

Compliance is checked during the heating tests of clause 14.

10.1.11 Terminals shall be so located that each core contained within any fixed wiring sheath or flexible cord sheath can be terminated in reasonable proximity to the other cores within the same sheath, unless there is a good technical reason for the contrary.

Compliance is checked by inspection.

10.1.12 Terminals for non-detachable cords using attachment methods X or M shall be so located or shielded, that should a wire escape when the conductors are fitted, there is no risk of accidental contact between live parts and accessible metal parts, and for class II controls and controls for class II equipment, between live parts and metal parts separated from accessible metal parts by supplementary insulation only. Furthermore, there shall be no risk of short-circuiting a declared action providing a full-disconnection or a micro-disconnection.

Compliance is checked by inspection and by the following test:

- *An 8 mm length of insulation is removed from the end of a stranded conductor having a nominal cross-sectional area equal to the minimum size used during the test of 10.1.4. One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal. The free wire is bent, without tearing the insulation back, in every direction, but without making sharp bends around barriers.*
- *The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible or is connected to an accessible metal part, or for class II controls and controls of class II equipment, any metal part which is separated from accessible metal parts by supplementary insulation only.*

- *The free wire of a conductor connected to an earthing terminal shall not touch any live part.*
- *The free wire of a conductor connected to a live terminal shall not become accessible, nor shall it short-circuit a declared action providing a full-disconnection or a micro-disconnection.*

10.1.13 Terminals shall be so designed that circuit continuity is not maintained by pressure transmitted through insulating material other than ceramic, or other insulating material with characteristics no less suitable, unless there is sufficient resilience in the appropriate metal parts to compensate for any shrinkage or distortion.

Compliance is checked by initial inspection and by further examination of the terminals when the samples have completed the test of clause 17.

The suitability of the material is considered in respect to the stability of the dimensions within the temperature range applicable to the control.

10.1.14 Screws and threaded parts of terminals shall be of metal.

Compliance is checked by inspection.

In some countries, national standards require that when screws are used for conductors of 2,5 mm or smaller diameter, the connection shall consist of clamps or binding screws with terminal plates having upturned lugs, or equivalent, to hold the wires in position. Terminal plate thicknesses are 1,27 mm (0,050 in) for wire size of more than 1,6 mm diameter (# 14 AWG); and 0,76 mm thickness minimum (0,030 in) for wire sizes of 1,6 mm or smaller diameter. The terminal screws shall not be smaller than # 8 Unified, except that # 6 Unified screw may be used for connection of a 1,29 mm (# 16) wire or a 1,02 mm (# 18) wire or a single 1,6 mm (# 14) wire.

10.1.15 Terminals of the pillar type and the mantle type shall be so designed as to allow an adequate length of conductor to be introduced into, and pass beyond the edge of the screw, to ensure that the conductor does not fall out.

Compliance is checked for pillar terminals by measurement of dimension "g" in figure 11 and for mantle terminals by the minimum distance specified in figure 12.

In the U.S.A. and Canada, the following subclauses apply:

10.1.16 Flying leads (pig tails)

In Canada and the U.S.A., where flying leads (pig tails) may be used for wiring connections of independently mounted controls, the lead wires shall not be smaller than 0,82 mm^2. The insulation shall be at least 0,8 mm thick, if thermoplastic, or at least 0,8 mm thick rubber, with a braid of 0,8 mm thick thermoplastic.

The leads shall have a minimum length of 150 mm and shall be arranged so that they are inaccessible when installed in accordance with national wiring practices. Additionally, the control end connection of such a lead, if located in the same wiring compartment, shall not be to a threaded terminal construction unless the means of connection is rendered unusable for connection of an external conductor.

The threaded terminal construction need not be rendered unusable if the lead is insulated at the connection end, and a marking on the device clearly indicates the intended use of the lead.

Compliance is checked by inspection.

10.1.16.1

In Canada and the U.S.A., flying leads shall be provided with strain relief to prevent mechanical stress from being transmitted to terminal, splices (e.g., twist-on connections) or internal wiring.

Compliance is checked by inspection and by applying a pull of 44 N on the leads for 1 min.

During this test, the lead shall not be damaged and shall not be displaced longitudinally by more than 2 mm.

10.2 Terminals and terminations for internal conductors

10.2.1 Terminals and terminations shall allow the connection of conductors having nominal cross-sectional areas as shown in table 10.2.1.

Table 10.2.1

Current carried by terminal or terminations A	Minimum nominal [1] cross-sectional area of conductor mm²
Up to and including 3	– [2]
over 3 up to and including 6	0,75
over 6 up to and including 10	1
over 10 up to and including 16	1,5
over 16 up to and including 25	2,5
over 25 up to and including 32	4
over 32 up to and including 40	6
over 40 up to and including 63	10

[1] In some countries other sizes of conductors apply.

[2] No minimum specified, but the manufacturer shall declare the conductor size for test purposes.

The requirements of 10.2.1 do not apply to terminals which are not intended to accept standard conductors without special preparation; or which, by their design and application, cannot accept standard conductors; or which are deliberately designed to accept conductors of a different size and which are for use only in particular types of equipment. An example is a thermostat intended for use within the fabric of an electric blanket.

10.2.2 Terminals and terminations shall be suitable for their purpose. Terminations for making soldered, crimped and welded connections shall be capable of withstanding the stresses which occur in normal service.

Compliance is checked by inspection.

10.2.3 When soldered terminals are used, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided such that creepage distances and clearances between live parts and other metal parts cannot be reduced to less than 50 % of the values specified in 20.1 should the conductor break away at the soldered joint.

Compliance is checked by inspection.

In general, "hooking-in" before soldering is considered to be a suitable means for maintaining a conductor in position, provided the hole through which the conductor is passed is not unduly large, and provided that the conductor is not part of a flat-twin tinsel cord.

Other methods of maintaining a conductor in position, such as waisting the sides of a solder tag, are also considered acceptable.

10.2.4 Flat push-on connectors

10.2.4.1 Tabs forming part of a control shall comply with the dimensional requirements of figure 14 or 15.

Compliance is checked by measurement.

Tabs with dimensions other than those shown in figure 14 or 15 are allowed, if the dimensions and shapes are so different as to prevent any possible mismating with a standard receptacle (see figure 16).

Tabs allowing the polarized acceptance of receptacles are allowed (see figure 16).

In some countries other dimensions may be used.

10.2.4.2 Tabs forming part of a control shall consist of material and plating appropriate to the maximum temperature of the tabs as indicated in table 10.2.4.2.

Table 10.2.4.2 – Material and plating for tabs

Material and plating of tabs	Maximum temperature of the tab °C
Bare copper	155
Bare brass	210
Tin plated copper and copper alloys	160
Nickel plated copper and copper alloys	185
Silver plated copper and copper alloys	205
Nickel plated steel	400
Stainless steel	400

Compliance is checked by measuring the temperatures attained during the tests of clause 14.

Materials or coatings other than those specified may be used provided their electrical and mechanical characteristics are no less reliable, particularly with regard to resistance to corrosion and mechanical strength.

The temperatures specified are those for continuous use. Higher transient temperatures are permitted, for example, during temperature overshoot of a temperature sensing control.

10.2.4.3 Tabs forming part of a control shall have adequate strength to allow the insertion and withdrawal of receptacles without damage to the control such as to impair compliance with this standard.

Compliance is checked by applying, without jerks, axial forces equal to those shown in table 10.2.4.3. No significant displacement nor damage shall occur.

Table 10.2.4.3

Tab size (see figure 16)	Push [1] N	Pull [1] N
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[1] The values in the above table are the maximum allowed for the insertion and the withdrawal of a receptacle from a tab.

10.2.4.4 Tabs forming part of a control shall be adequately spaced to allow the connection of the appropriate receptacles.

Compliance is checked by applying an appropriate receptacle on each tab unless otherwise declared in 7.2. During this application no strain nor distortion shall occur to any of the tabs nor to their adjacent parts, nor shall the creepage or clearance values be reduced below those specified in clause 20.

For tabs complying with figure 14 or 15, the appropriate receptacle is shown in figure 16.

10.3 Terminals and terminations for integrated conductors

There are no specific requirements or tests for terminals or terminations for integrated conductors under clause 10, but the relevant requirements of the other clauses may apply.

11 Constructional requirements

11.1 Materials

11.1.1 Insulating materials – Impregnated

Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation unless impregnated.

Compliance is checked by inspection.

Insulating material is considered to be impregnated if the interstices between the fibres of the materials are substantially filled with a suitable insulant.

11.1.2 Current-carrying parts

If brass is used for current carrying parts other than threaded parts of terminals, it shall contain at least 50 % copper if the part is cast or made from bar, or at least 58 % if the part is made from rolled sheet.

Compliance is checked by inspection and by analysis of the material.

11.1.3 Non-detachable cords

11.1.3.1 Non-detachable cords of class I controls shall have a green/yellow conductor insulation which is connected to the earthing terminal or termination of the control, or to the earthing contact of any equipment inlet or socket-outlet, if provided.

11.1.3.2 Conductor insulation identified by the color combination green/yellow shall not be connected to terminals or terminations other than earthing terminals or terminations.

Compliance with 11.1.3.1 and 11.1.3.2 is checked by inspection.

11.2 Protection against electric shock

11.2.1 Double insulation

When double insulation is employed, the design shall be such that the basic insulation and the supplementary insulation can be tested separately unless satisfaction with regard to the properties of both insulations is provided in another way.

11.2.1.1 If the basic and the supplementary insulation cannot be tested separately, or if satisfaction with regard to the properties of both insulations cannot be obtained in another way, the insulation is regarded as reinforced insulation.

Compliance is checked by inspection and by test.

Specially prepared samples, or samples of the insulating parts, are regarded as ways of providing satisfaction.

11.2.2 Infringement of double or reinforced insulation

Class II controls and controls for use in class II equipment shall be so designed that creepage distances and clearances over supplementary insulation or reinforced insulation cannot, as a result of wear, be reduced below the values specified in clause 20. They shall be so constructed that if any wire, screw, nut, washer, spring, flat push-on receptacle or similar part becomes loose and falls out of position, it cannot in normal use become so disposed that creepage distances or clearances over supplementary insulation or reinforced insulation are reduced to less than 50 % of the value specified in clause 20.

Compliance is checked by inspection, by measurement and/or by manual test.

For the purpose of this requirement:

- *it is not to be expected that two independent fixings will become loose at the same time;*
- *parts fixed by screws or nuts provided with a locking washer are regarded as not liable to become loose, provided these screws or nuts are not required to be removed during user maintenance or servicing;*
- *springs and spring parts that do not become loose or fall out of position during the tests of clauses 17 and 18 are deemed to comply;*
- *wires connected by soldering are considered to be not adequately fixed unless they are held in place near to the termination, independently of the solder;*
- *wires connected to terminals are considered to be not adequately secured unless an additional fixing is provided near to the terminal. This additional fixing, in the case of stranded conductors, shall clamp the insulation and not the conductor;*
- *short rigid wires are regarded as not liable to come away from a terminal if they remain in position when any one terminal screw or nut is loosened.*

11.2.3 Integrated conductors

11.2.3.1 Integrated conductors shall be so rigid, so fixed or so insulated that in normal use creepage distances and clearances cannot be reduced below the values specified in clause 20.

11.2.3.2 Insulation, if any, shall be such that it cannot be damaged during mounting or in normal use.

Compliance with 11.2.3.1 and 11.2.3.2 is checked by inspection, by measurement and by manual test.

If the insulation on a conductor is not at least electrically equivalent to that of cables and flexible cords complying with the appropriate IEC standard, or alternatively does not comply with the electric strength test made between the conductor and metal foil wrapped around the insulation under the conditions specified in clause 13, the conductor is considered to be a bare conductor.

11.2.4 Flexible cord sheaths

Inside a control, the sheath (jacket) of a flexible cable or cord shall be used as supplementary insulation only where it is not subject to undue mechanical or thermal stresses, and if its insulating properties are not less than those specified in IEC 60227 or IEC 60245.

Compliance is checked by inspection, and, if necessary, by testing the sheaths of the flexible cords according to IEC 60227 or IEC 60245.

11.2.5 See annex H.

11.3 Actuation and operation

11.3.1 Full disconnection

Controls with positions declared as full-disconnection shall be so designed that in the declared positions there is contact separation in all supply poles other than earth, at least equal to the relevant values specified in clause 20. The contact separation may be obtained by automatic action or by manual action, but any subsequent automatic action shall not cause any contact separation to be reduced below the specified minimum.

If the disconnection is also declared to provide all-pole disconnection, the contact operation in each supply pole shall be substantially together.

Compliance is checked by inspection and by the tests of clauses 13 and 20, where necessary.

11.3.2 Micro-disconnection

Controls with positions declared as micro-disconnection shall be so designed that in the declared positions there is contact separation in at least one supply pole to meet the electric strength requirements of clause 13 but no clearance dimension is specified. The contact separation may be obtained by automatic action or by manual action, but any subsequent change of activating quantity between the limits declared in 7.2, requirement 36, or at any switch head temperature between the limits declared in 7.2, requirement 22, shall not cause an operation which would reduce the contact separation such that the requirements of clause 13 are no longer met.

Compliance is checked by inspection and, where necessary, by the tests of clause 13 carried out at the temperature limits declared.

11.3.3 Reset buttons

Reset buttons of controls shall be so located or protected that they are not likely to be accidentally reset.

Compliance is checked by inspection.

This requirement precludes, for example, reset buttons mounted in such a position that they can be reset by pushing the control against a wall, or by pushing a piece of furniture against the control.

This requirement does not apply to manual reset controls with trip-free actions.

11.3.4 Setting by the manufacturer

Parts used for the setting of controls by the manufacturer shall be secured to prevent accidental shifting after setting.

Compliance is checked by inspection.

11.3.5 Contacts – General

Contacts with a d.c. rating greater than 0,1 A, which can be operated by actuation, shall be so designed that the speeds of approach and separation of the contact surfaces are independent of the speed of actuation.

Compliance is checked by inspection.

This requirement does not apply to contacts excluded by 11.3.7.

11.3.6 Contacts for full-disconnection and micro-disconnection

Contacts for full-disconnection and contacts for micro-disconnection, having either a d.c. rating not greater than 0,1 A, or an a.c. rating, and which can be operated by actuation, shall be so designed that they can come to rest only in a closed position or in an open position.

Compliance is checked by inspection, and for a closed position by the temperature requirements of clause 14, and for open position by the requirements of clause 13, as specified for micro-disconnection. However, where an intermediate position of the actuating member occurs adjacent to a located position declared as full-disconnection, then the tests of clauses 13 and 20, as specified for full-disconnection, are made for this intermediate position.

11.3.7 The requirements of 11.3.5 and 11.3.6 shall not apply to contacts where inspection shows they cannot be operated on-load or are not intended to be operated on-load, nor to contacts which do not arc under conditions of normal use.

11.3.7.1 *Compliance is checked by inspection, and if necessary by the test of 11.3.7.2.*

11.3.7.2 *A d.c. voltage equal to the maximum working voltage is applied to the contacts in series with a resistor such that the current occurring in normal use is obtained. It shall not be possible to maintain an arc by slowly opening the contacts.*

11.3.8 Contacts rest position

Contacts shall, in any rest position of the actuating member, be either open or closed as intended, or such that no hazard can occur within the control or equipment.

Compliance is checked by inspection.

The term "rest position of the actuating member" includes located, intermediate and position of setting by the user.

11.3.9 Pull-cord actuated control

A pull-cord actuated control shall be so designed that when the pull-cord is released after actuating the control, the relevant parts of the mechanism normally cannot fail to return to a position from which they allow the immediate performance of the next movement in the cycle of actuation of the control.

Compliance is checked by inspection and by the following test.

Pull-cord actuated controls shall be actuated from any located position to the next located position by the application and removal of a steady pull not exceeding 45 N vertically downwards, or 70 N at 45° to the vertical, with the control mounted in any declared manner.

The actuating forces for controls actuated by other than pull cords, are not specified. Attention is drawn to the relevant equipment standard where such requirements may be given.

11.4 Actions

11.4.1 Combined actions

A control having more than one action, with one of the actions designed to operate after the failure of the other action(s), shall be so constructed that this action remains operative after failure of any portion unique to the other action(s).

Compliance is checked by inspection and, if necessary, by tests after making all of the other action(s) inoperative.

11.4.2 Setting by the manufacturer

Type 2 action which has provision for setting by the manufacturer of its operating value, operating time or operating sequence, shall be designed such that it is clearly discernible if any subsequent interference with the setting has been made.

Compliance is checked by inspection.

11.4.3 Type 2 action

Any Type 2 action shall be so designed that the manufacturing deviation and drift of its operating value, operating time or operating sequence is within the limit declared in requirements 41 and 42 of table 7.2.

Compliance is checked by the tests of clauses 15 to 17 inclusive.

11.4.4 Type 1.A or 2.A action

A Type 1.A or 2.A action shall operate to provide the clearances and electric strength requirements specified for full-disconnection.

Compliance is checked by the tests of clause 13 and the relevant requirements of clause 20.

11.4.5 Type 1.B or 2.B action

A Type 1.B or 2.B action shall operate to provide the electric strength requirements specified for micro-disconnection.

Compliance is checked by the test of clause 13 and the relevant requirements of clause 20.

11.4.6 Type 1.C or 2.C action

A Type 1.C or 2.C action shall operate to provide circuit interruption by micro-interruption.

Compliance is checked by the relevant requirements of clause 20.

11.4.7 Type 1.D or 2.D action

A Type 1.D or 2.D action shall be so designed that disconnection can neither be prevented nor inhibited, by any reset mechanism and so that after disconnection, it is not possible to reclose the circuit even momentarily while the excess or fault condition persists.

Compliance is checked by inspection and by test.

11.4.8 Type 1.E or 2.E action

A Type 1.E or 2.E action shall be designed so that disconnection can neither be prevented, nor inhibited by any reset mechanism and so that the contacts can neither be prevented from opening nor be maintained closed against a continuation of the excess or fault condition.

Compliance is checked by inspection and by test.

11.4.9 Type 1.F or 2.F action

A Type 1.F or 2.F action shall be designed so that after the control has been mounted in accordance with the manufacturers' instructions, it can only be reset with the aid of a tool.

Compliance is checked by inspection and by test.

Mounting within an equipment such that a tool is required to gain access to the control is deemed to satisfy this requirement.

11.4.10 Type 1.G or 2.G action

A Type 1.G or 2.G action shall be designed so that after the control has operated, it is possible to reset the control (although not intended) under electrically loaded conditions.

Compliance is checked by inspection and by resetting once at rated voltage and rated current.

11.4.11 Type 1.H or 2.H action

A Type 1.H or 2.H action shall be so designed that the contacts cannot be prevented from opening and which may automatically reset to the closed position if the reset means is held in the reset position. The control shall not reset automatically at any temperature above –35 °C with the reset mechanism in the normal position.

Compliance is checked by inspection and by test.

11.4.12 Type 1.J or 2.J action

A Type 1.J or 2.J action shall be so designed that the contacts cannot be prevented from opening, and the control is not permitted to function as an automatic reset device if the reset means is held in the reset position. The control shall not reset automatically at any temperature above –35 °C.

Compliance is checked by inspection and by test.

11.4.13 Type 1.K or 2.K action

A Type 1.K or 2.K action shall be so designed that in the event of a break in the sensing element, or in any other part between the sensing element and the switch head, the declared disconnection is provided before the declared operating value, operating time or operating sequence is exceeded.

The test is given in the relevant Part 2.

11.4.14 Type 1.L or 2.L action

A Type 1.L or 2.L action shall be so designed that in the case of failure of the electrical supply, it performs its intended function independently of any external auxiliary energy source or electrical supply.

Compliance is checked by inspection.

A simple direct acting spring or weight is not regarded as an auxiliary energy source or electrical supply.

11.4.15 Type 1.M or 2.M action

A Type 1.M or 2.M action shall be so designed that it operates in its intended manner after the declared ageing procedure.

Compliance is checked by the test of 17.6.

11.4.6 See annex H.

11.5 Openings in enclosures

Drain holes, if any, shall have a minimum area of 20 mm^2, a maximum area of 40 mm^2 and minimum dimension of 3 mm.

Compliance is checked by inspection.

Additional requirements for moisture resistance are contained in clause 12.

Controls classified as IPX7 may have a facility for opening a drain hole.

In some countries, there are additional requirements for openings in enclosures provided for ventilation, drainage, mounting of components, or clearance around a dial, knob, lever, handle, capillary tube or the like.

11.6 Mounting of controls

11.6.1 Controls shall be so designed that the methods of mounting in accordance with the manufacturer's declaration do not adversely affect compliance with this standard.

11.6.2 Declared methods of mounting shall be such that the control cannot rotate or be otherwise displaced, and cannot be removed from an equipment without the aid of a tool, if such movement or removal could adversely affect compliance with this standard. If removal or partial removal is necessary for correct use of the control, then the requirements of clauses 8, 13 and 20 shall be satisfied before and after removal.

Compliance with 11.6.1 and 11.6.2 is checked by inspection and by manual test.

Controls, other than those with rotary actuation, fixed by a nut and single bushing concentric with the actuating means, are deemed to comply with this requirement, provided that the tightening of the nut requires the use of a tool, and that the parts have adequate mechanical strength. An incorporated control mounted by screwless fixing is deemed to comply with this requirement if the use of a tool is required before the control can be removed from the equipment.

11.6.3 Mounting of independently mounted controls

11.6.3.1 Independently mounted controls other than those declared for panel mounting shall either:

- fit a standard box as declared;
- be supplied with a conduit box if a special conduit box is required; or
- be suitable for surface mounting on a plane surface.

11.6.3.2 If a special conduit box is required, it shall be delivered together with the control and the box shall be provided with the entries for conduit specified in IEC 60423.

11.6.3.3 Independently mounted controls for surface mounting used with buried installation (concealed wiring) not using an outlet box shall be provided with suitable holes on the back of the control allowing easy installation and connection to the terminals.

11.6.3.4 Independently mounted controls for surface mounting used with exposed wiring shall be provided with cable or conduit entries, knock-outs, or glands, which allow connection of the appropriate type of cable or conduit complying with the relevant IEC standard.

11.6.3.5 Independently mounted controls for surface mounting or the sub-bases for such controls, shall be constructed in such a manner that the terminals for external conductors are accessible and can be used when the control or the sub-base is correctly fixed to its support and its cover (or the control) is removed.

11.6.3.6 Controls intended for mounting on an outlet box or similar enclosure shall have wiring terminals, other live parts and sharp-edged metal parts, earthed or not, located or protected so that they will not be forced against wiring in the box or enclosure during installation of the control.

11.6.3.7 Where back wiring terminals are used, they shall be recessed or be protected by close-fitting barriers or insulating materials or the equivalent that will prevent contact with wiring installed in the box.

Compliance with 11.6.3.1 to 11.6.3.7, inclusive, is checked by inspection.

Terminals that do not project into the box beyond the plane of the front edge of the box are acceptable.

Guards provided alongside terminals and extending at least 6,5 mm beyond the terminals before wiring, with a corresponding guard between double pole mechanism, are acceptable.

11.7 Attachment of cords

11.7.1 Flexing

11.7.1.1 The flexible cords of in-line cord and free standing controls shall be capable of withstanding the flexing likely to occur in normal use. If a cord-guard is provided to meet this requirement it shall not be integral with the flexible cord if attachment method X is used.

11.7.1.2 *Compliance is checked by subjecting the control, fitted with the flexible cord or range of flexible cords for which it is designed, to the following test:*

11.7.1.2.1 *The control is mounted in the flexing apparatus shown in figure 9. The axis of oscillation is so chosen that the weight attached to the cord and the cord itself make the minimum lateral movement during the test.*

Samples with flat cords are mounted so that the major axis of the cross-section is parallel to the axis of oscillation. Each flexible cord passing through the inlet opening is loaded with a weight of 1 kg. A current equal to the current passing through that particular core when the control is operated at rated voltage is passed through each core, the voltage between cores being maximum rated voltage. The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical). The number of flexings (that is one movement through 90°) being 5 000, and the rate of the flexing being 60 flexings per minute.

11.7.1.2.2 *After the test, the sample shall show no damage within the meaning of this standard. During the test, no interruption of the current and no short circuit between the individual conductors shall occur, neither shall broken strands pierce the insulation to the outer surface of the accessory. A short circuit between individual conductors is considered to occur if the current reaches twice the value of the test current.*

11.7.1.2.3 *Not more than 10 % of the total number of conductors of the flexible cord shall have been broken.*

11.7.2 Cord anchorages

11.7.2.1 Controls other than those integrated and incorporated, intended to be connected by means of a non-detachable cord, shall have cord anchorages such that the conductors are relieved from strain, including twisting, where they are connected to the terminals, and that their covering is protected from abrasion. It shall be clear how the relief from strain and the prevention of twisting is intended to be effected.

11.7.2.2 Cord anchorages of class II controls shall be of insulating material or, if of metal, be insulated from accessible metal parts or metal foil over accessible non metallic surfaces by insulation complying with the requirements for supplementary insulation.

11.7.2.3 Cord anchorages of controls, other than those of class II, shall be of insulating material or be provided with an insulating lining, if otherwise an insulation fault on the cord could make accessible metal parts live. This lining, if any, shall be fixed to the cord anchorage, unless it is a bushing which forms part of a cord guard provided to meet the requirements of 11.7.1.

11.7.2.4 Cord anchorages shall be so designed that:

- the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible metal parts;
- the cord is not clamped by a metal screw which bears directly on the cord;
- for attachment method X or M at least one part is securely fixed to the control;
- for attachment method X or M replacement of the flexible cord does not require the use of a special purpose tool;
- for attachment method X they are suitable for the different types of flexible cord which may be connected;
- for attachment method X the design and location make replacement of the flexible cord easily possible.

11.7.2.5 For other than attachment method Z, makeshift methods such as tying the cord into a knot, or tying the ends with string, shall not be used.

11.7.2.6 Glands shall not be used as cord anchorages in in-line cord controls using attachment method X unless they make provision for clamping all types and sizes of cords used in 10.1.4.

11.7.2.7 Screws, if any, which have to be operated when replacing the cord, shall not serve to fix any other component, unless either the control is rendered inoperable or manifestly incomplete if they are omitted or incorrectly replaced, or the component intended to be fixed cannot be removed without the aid of a tool when replacing the flexible cord.

11.7.2.8 *Compliance with 11.7.2.1 to 11.7.2.7, inclusive, is checked by inspection and by the tests of 11.7.2.9 to 11.7.2.15 inclusive.*

11.7.2.9 *The control is fitted with a flexible cord and the conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the intended manner, the screws being tightened with a torque equal to two-thirds of the torque specified in 19.1.*

11.7.2.10 *After this preparation, it shall not be possible to push the cord into the control to such an extent that the cord or internal parts of the control could be damaged, or that internal parts are interfered with in a way which might impair compliance with this standard.*

11.7.2.11 *The cord is then subjected to pulls of the value and number shown in table 11.7.2. The pulls are applied in the most unfavorable direction, without jerks, each time for 1 s.*

11.7.2.12 *Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in table 11.7.2.*

Table 11.7.2

Control	Pull [1)] N	Torque [1)] Nm	Number of pulls [1)]
Free-standing controls:			
Up to and including 1 kg	30	0,1	25
Over 1 kg up to and including 4 kg	60	0,25	25
Over 4 kg	100	0,35	25
In-line cord controls: (other than free-standing controls)	90	0,25	100

[1)] Some equipment standards may require a different value.

11.7.2.13 *For attachment method X, the tests are made first with the lightest permissible type of flexible cord of the smallest cross-sectional area used in 10.1.4, and then with the next heavier type of flexible cord of the largest cross-sectional area used. For attachment methods M, Y or Z only declared or fitted cord is used.*

11.7.2.14 *During the tests, the cord shall not be damaged. After the tests the cord shall not have been displaced longitudinally by more than 2 mm, the conductors shall not have been moved over a distance of more than 1 mm in the terminals, and there shall be no appreciable strain at the connection. Creepage distances and clearances shall not have been reduced below the value specified in clause 20.*

11.7.2.15 For the measurement of the longitudinal displacement, a mark is made on the cord while it is subjected to the pull, at a distance of approximately 20 mm from the cord anchorage, before starting the tests. After the tests, the displacement of the mark on the cord in relation to the cord anchorage is measured while the cord is subjected to the pull.

11.8 Size of cords – non-detachable

11.8.1 Non-detachable cords shall not be lighter than ordinary tough rubber sheathed flexible cord, designated 60245 IEC 53, or ordinary polyvinyl chloride sheathed flexible cord, designated 60227 IEC 53, except that the use of a lighter flexible cord is permissible if allowed in a particular equipment standard.

Compliance is checked by inspection.

11.8.2 Controls fitted with non-detachable cords shall have a cord with conductors of a size not less than that shown in table 11.8.2.

Table 11.8.2

Current in relevant circuit A	Nominal cross-sectional area [1] mm^2
Up to and including 6 [2]	0,75
over 6 up to and including 10	1
over 10 up to and including 16	1,5
over 16 up to and including 25	2,5
over 25 up to and including 32	4
over 32 up to and including 40	6
over 40 up to and including 63	10

[1] In some countries other sizes of conductors apply.

[2] Lower values than 0,75 mm^2 are only permitted for class III controls or if permitted in a particular equipment standard.

Compliance is checked by inspection.

11.8.3 The space for the flexible cord inside the control shall be adequate to allow the conductors to be easily introduced and connected, and the cover, if any, fitted without risk of damage to the conductors or their insulation. It shall be possible to check that the conductors are correctly connected and positioned before the cover is fitted.

Compliance is checked by inspection and by connecting cords of the largest cross-sectional area used in 10.1.4.

11.9 Inlet openings

11.9.1 Inlet openings for flexible external cords shall be so designed and shaped, or shall be provided with an inlet bushing, so that the covering of the cord can be introduced without risk of damage.

11.9.1.1 Conduit entries and knock-outs of independently mounted controls shall be so designed or located that introduction of the conduit or conduit fitting does not affect the protection against electric shock or reduce creepage distances and clearances below the values specified in clause 20.

Compliance is checked by inspection.

11.9.2 If an inlet bushing is not provided then the inlet opening shall be of insulating material.

11.9.3 If an inlet bushing is provided then it shall be of insulating material, and:

- shall be so shaped as to prevent damage to the cord,
- shall be reliably fixed,
- shall not be removable without the aid of a tool,
- shall, if attachment method X is used, not be integral with the cord.

11.9.4 An inlet bushing shall not be of rubber, with the exception that for attachment methods M, Y and Z for class 0, class 0I or class I controls, rubber is allowed if the bushing is integral with the sheath of a cord of rubber.

Compliance with 11.9.1 to 11.9.4, inclusive, is checked by inspection and manual test.

11.9.5 Enclosures of independently mounted controls intended to be permanently connected to fixed wiring shall have cable entries, conduit entries, knockouts or glands which permit the connection of the appropriate conduit, cable or cord, as applicable.

11.10 Equipment inlets and socket-outlets

11.10.1 The design of equipment inlets and socket-outlets intended for use by the user for the interconnection of controls and equipment shall be such as to render unlikely their engagement with each other or with equipment inlets or socket-outlets intended for other systems if such engagement could result in fire, or injury or electric shock to persons or damage to equipment or surroundings.

Compliance is checked by inspection.

11.10.2 In-line cord controls provided with an equipment inlet or socket-outlet shall be so rated, or so protected, that unintentional overloading of either the control, equipment inlet or socket-outlet cannot occur in normal use.

Compliance is checked by inspection.

11.10.3 Controls provided with pins, blades, or other connecting/adapting means, in order to be introduced into fixed socket outlets shall comply with the requirements of the appropriate socket-outlet system.

Compliance is checked by inspection and by carrying out tests based on those prescribed for the socket-outlet system.

11.11 Requirements during mounting, maintenance and servicing

11.11.1 Covers and their fixing

11.11.1.1 For other than integrated controls, the removal of a cover or cover plate, which is intended to be removed during mounting, user maintenance or servicing of the control or equipment, shall not affect the setting of the control if this might impair compliance with this standard.

11.11.1.2 The fixing of covers shall be such that they cannot be displaced, nor replaced incorrectly if this could mislead the user or would impair compliance with this standard. The fixing of covers which need to be removed for mounting shall not serve to fix any parts, other than actuating members or gaskets.

Compliance with 11.11.1.1 and 11.11.1.2 is checked by inspection.

In some countries, a screwless fixed cover which gives access to bare live parts and which does not require a tool for its removal shall withstand the following tests:

A cover shall not become disengaged from the case when a direct pull of 60 N is applied. For this test, the cover is to be gripped at any two convenient points. The test shall be performed before and after 10 removal and replacement operations.

A cover shall be capable of withstanding an impact of 1,35 Nm applied to the accessible faces of the cover (one blow per face) without being displaced, and there shall be no damage to internal parts nor malfunction of the control as a result of this test. The radius of the ball used for this test shall be not less than 25,4 mm.

In some countries, the continuity of the earthing means for a screwless fixed cover shall comply with the requirements of 9.3 and 9.5.

11.11.1.3 Covers of enclosures

In Canada and the U.S.A., there are additional requirements for doors or covers of enclosures giving access to fuses or any overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the overload protective device.

11.11.1.4 Glass covering an opening

In Canada and the U.S.A., there are additional requirements for glass or glass-like material covering an observation opening.

11.11.1.5 Non-detachable parts

Non-detachable parts which provide the necessary degree of protection against electric shock, moisture or contact with moving parts, shall be fixed in a reliable manner and shall withstand the mechanical stress occurring in normal use.

Snap-in devices used for fixing non-detachable parts shall have an obvious locked position. The fixing properties of snap-in devices used in parts which are likely to be removed for installation or during servicing shall not deteriorate.

Compliance is checked by the tests of 11.11.1.5.1 to 11.11.1.5.3.

11.11.1.5.1 *Parts which are likely to be removed for installation or during servicing are disassembled and assembled 10 times before the test is carried out.*

Servicing includes replacement of the supply cord.

11.11.1.5.2 *For the tests of 11.11.1.5.3, the control shall be at room temperature. However, in cases where compliance may be affected by temperature, the test is also carried out immediately after the control has been operated under the conditions specified in clause 14.*

11.11.1.5.3 *A force is applied for 10 s, without jerks, in the most unfavourable direction, to those areas of the cover or part which are likely to be weak. The force to be used shall be as follows:*

– *Push force*	*50 N*
– *Pull force, as follows:*	
a) If the shape of the part is such that the fingertips cannot easily slip off	*50 N*
b) If the projection of the part which is gripped is less than 10 mm in the direction of removal	*30 N*

The push force is applied by means of a rigid test finger similar in dimensions to the standard test finger shown in figure 2.

The pull force is applied by any suitable means (e.g., a suction cup) so that the test results are not affected.

While the pull test of a) or b) is being applied, the test fingernail shown in figure 3 is inserted in any aperture or joint with a force of 10 N. The fingernail is then slid sideways with a force of 10 N; it is not twisted or used as a lever.

If the shape of the part is such that an axial pull is unlikely, no pull force is applied but the test fingernail shown in figure 3 is inserted in any aperture or joint with a force of 10 N and is then pulled for 10 s by means of the loop with a force of 30 N in the direction or removal.

If the cover or part is likely to be subjected to a twisting force, a torque as detailed below shall be applied at the same time as the pull or push force:

– *for major dimensions up to and including 50 mm*	*2 Nm*
– *for major dimensions over 50 mm*	*4 Nm*

This torque is also applied when the test fingernail is pulled by means of the loop.

If the projection of the part which is gripped is less than 10 mm, the above torque is reduced to 50 % of the value.

11.11.1.5.4 *During and after the tests of 11.11.1.5.3, parts shall not become detached and they shall remain in the locked position, otherwise they are deemed to be detachable parts.*

11.11.1.6 A cover, which can be removed with one hand, shall not be released when a squeezing force of up to 45 N combined with up to 15 N for the pull test is applied at any two points, the distance between which does not exceed 125 mm, as measured by a tape stretched tightly over that portion of the surface of the cover which would be encompassed by the palm of the hand. The test is performed before and after 10 removal and replacement operations.

11.11.2 Cover fixing means

Fixing screws of covers or cover plates which need to be removed during mounting, user maintenance or servicing shall be captive.

Compliance is checked by inspection.

The use of tight-fitting washers of cardboard or similar material is deemed to meet this requirement. See 19.1.5.

11.11.3 Actuating member

11.11.3.1 A control shall not be damaged when its actuating member is mounted or removed in the intended manner.

11.11.3.2 If the maximum or minimum setting by manufacturer or user of a Type 2 action is limited by mechanical means associated with an actuating member, such actuating member shall not be removable without the use of a tool.

11.11.3.3 If an actuating member of a control with a Type 1 action providing an "OFF" position, or the actuating member of any control with a Type 2 action is used to indicate the condition of the control, it shall not be possible to fix the actuating member in an incorrect position.

Compliance with 11.11.3.1 to 11.11.3.3 inclusive is checked by inspection and, for actuating members which do not require a tool for their removal, by the test of 18.9.

Standards for equipment may require that an actuating member used to indicate the condition of a control shall not be capable of being fixed in an incorrect position.

11.11.4 Parts forming supplementary or reinforced insulation

Parts of controls which serve as supplementary insulation or reinforced insulation and which might be omitted during reassembly after user maintenance or servicing, shall either be fixed in such a way that they cannot be removed without being seriously damaged, or be so designed that they cannot be replaced in an incorrect position, and that, if they are omitted, the control is rendered inoperable or manifestly incomplete.

Compliance is checked by inspection.

Lining metal enclosures with a coating of lacquer, or with other material in the form of a coating which can be easily removed by scraping, is not deemed to meet this requirement.

11.11.5 Sleeving as supplementary insulation

Sleeving used as supplementary insulation on integrated conductors shall be retained in position by a positive means.

Compliance is checked by inspection and by manual test.

A sleeve is considered to be fixed by a positive means if it can only be removed by breaking or cutting, or if it is clamped.

11.11.6 Pull-cords

Pull-cords shall be insulated from live parts and the control shall be so designed that it is possible to fit or to replace the pull-cord without live parts becoming accessible.

Compliance is checked by inspection.

11.11.7 Insulating linings

Insulating linings, barriers and the like shall have adequate mechanical strength and shall be secured in a reliable manner.

Compliance is checked by inspection.

11.12 Controls using software

See annex H.

12 Moisture and dust resistance

12.1 Protection against ingress of water and dust

12.1.1 Controls shall provide the degree of protection against ingress of water and dust appropriate to their IP classification when mounted and used in the declared manner.

12.1.2 *Compliance is checked by first preparing the control as described in 12.1.3 to 12.1.6 inclusive and then by carrying out the appropriate test specified in IEC 60529. Immediately after the appropriate test the control shall withstand the electric strength test specified in 13.2, and inspection shall show that any water which may have entered the control has not impaired compliance with this standard: in particular, there shall be no trace of water on insulation which could result in reduction of creepage distances and clearances below the values specified in clause 20.*

12.1.3 *Controls are allowed to stand in normal test room atmosphere for 24 h before being subjected to the appropriate test.*

12.1.4 *Controls provided with a detachable cord are fitted with an appropriate equipment inlet and flexible cord; controls with a non-detachable cord using attachment method X are fitted with the appropriate conductors with the smallest cross-sectional area specified in 10.1.4; controls provided with a non-detachable cord using attachment methods M, Y or Z are tested with the cord declared or delivered with the samples.*

12.1.5 *Detachable parts are removed and subjected, if necessary, to the tests with the main part.*

12.1.6 *Sealing rings of glands and other sealing means, if any, are aged in an atmosphere having the composition and pressure of the ambient air, by suspending them freely in a heating cabinet, ventilated by natural circulation. They are kept in the cabinet at a temperature of (70 ± 2) °C, for 10 days (240 h).*

In some countries there are additional requirements for gaskets, glands and sealing compounds employed to prevent harmful ingress of water and to adhesives used for securement of such gaskets to an enclosure or cover in controls to be installed where exposed to rain and operating at or below 60 °C.

12.1.6.1 Void

12.1.6.2 *Immediately after ageing, the parts are taken out of the cabinet and left at room temperature, avoiding direct daylight, for at least 16 h, before being reassembled. The glands and other sealing means are then tightened with a torque equal to two-thirds of that given in the table of 19.1.*

12.2 Protection against humid conditions

12.2.1 All controls shall withstand humid conditions which may occur in normal use.

See also annex J.

12.2.2 *Compliance is checked by the test sequence described in 12.2.3, after the humidity treatment of 12.2.5 to 12.2.9, inclusive.*

12.2.3 *For in-line cord, free-standing, independently mounted controls, the test of 13.2 is conducted immediately after the humidity treatment. For integrated and incorporated controls, the test of 13.2 is conducted immediately after the humidity treatment. These tests shall be conducted in such a manner that condensation does not occur on any surface of the test samples.*

12.2.4 *The control shall show no damage so as to impair compliance with this standard.*

12.2.5 *Cable inlet openings, if any, and drain holes are left open. If a drain hole is provided for an IPX7 control, it is opened.*

12.2.6 *Detachable parts are removed and subjected, if necessary, to the humidity treatment with the main part.*

12.2.7 *Before being placed in the humidity cabinet, the sample is brought to a temperature between t and (t + 4) °C. The sample is then kept in the humidity cabinet for:*

- *2 days (48 h) for IPX0 controls;*
- *7 days (168 h) for all other controls.*

12.2.8 *The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity between 91 % and 95 %. The temperature of the air, at all places where samples can be located, is maintained within 1 °C of any convenient value (t) between 20 °C and 30 °C.*

12.2.9 *After this treatment the tests of clause 13 are made either in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature after the reassembly of any detached parts.*

In most cases the sample may be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.

A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air. Care should be taken such that the test sample is not subjected to condensate or other contaminants from the salt solution or from any part of the test equipment.

In order to achieve the specified conditions within the cabinet, it is necessary to provide constant circulation of the air within and, in general, to use a cabinet which is thermally insulated.

12.3 For in-line cord and free-standing controls, one sample is subjected to the test of 12.3.1 to 12.3.7 inclusive prior to the other tests of clause 12.

Class III controls are not tested under these subclauses.

12.3.1 *The control is connected to a supply voltage equal to 1,06 times the rated voltage. The test is conducted at the maximum rated current and the maximum declared ambient temperature.*

12.3.2 *The leakage current is measured between parts as indicated in 13.3.1 and measurements are made as indicated in this subclause and in 13.3.1.*

12.3.3 *Measuring circuits for controls using different supplies are shown in the figures mentioned below:*

- *for a single-phase control having a rated voltage not exceeding 250 V, or three-phase control used as a single-phase control, if a class II, see figure 25; if other than a class II see figure 26;*
- *for a single-phase control having a rated voltage exceeding 250 V, or a three-phase control not suitable for use as a single-phase control, if a class II control, see figure 27; if other than a class II control see figure 28;*
- *for a two-phase control having a rating not exceeding 250 V, other than class II, see figure 29 or 30, depending upon usage.*

Controls for single-phase equipment having a rated voltage exceeding 250 V shall be connected to two of the phase conductors, the remaining phase conductor not being used.

A suitable measuring circuit is shown in annex E.

12.3.4 *During measurement all control circuits shall be closed. However, controls tested according to figures 26, 29 and 30 shall have leakage currents checked with switch S1 in the open and the closed position.*

It is permissible to short circuit contact points to simulate closed circuits.

12.3.5 *The measuring circuit shall have a total impedance of (1 750 ± 250) Ω and be shunted by a capacitor such that the time constant of the circuit is (225 ± 15) µs.*

12.3.6 *The measurement circuit shall not have an error of more than 5 % at an indicated 0,75 mA of leakage and shall have an accuracy of within 5 % for all frequencies in the range of 20 Hz to 5 kHz.*

12.3.7 *The maximum leakage current, after the temperature of the control has stabilized, shall not exceed the values given in 13.3.4.*

13 Electric strength and insulation resistance

13.1 Insulation resistance

The insulation resistance of in-line cord, free standing and independently mounted controls shall be adequate.

13.1.1 *Compliance is checked by the test of 13.1.2 to 13.1.4 inclusive. This test is made when specified in clause 12.*

13.1.2 *When measuring reinforced or supplementary insulation to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.*

13.1.3 *The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

13.1.4 *The insulation resistance shall not be less than that shown in table 13.1.*

Table 13.1

Insulation to be tested	Insulation resistance MΩ
Operational insulation	–
Basic insulation	2
Supplementary insulation	5
Reinforced insulation	7

13.2 Electric strength

The electric strength of all controls shall be adequate.

13.2.1 *Compliance is checked by the following test of 13.2.2 to 13.2.4 inclusive. This test is made when specified in clause 12 and clause 17.*

Table 13.2 [14)]

Insulation or disconnection to be tested [5)] [9)]	Test voltage for working voltages [10)]				
	Up to 50 V	Over 50 V up to and including 130 V	Over 130 V up to and including 250 V	Over 250 V up to and including 440 V	Over 440 V
Operational insulation	500	1 000	1 250	1 250	2 000
Basic insulation [3)] [6)]	500	1 000	1 250	1 250	2 500
Supplementary insulation [3)] [6)] [7)]	–	1 500	2 500	2 500	3 000
Reinforced insulation [3)] [6)] [7)] [8)]	500[1)]	2 500	3 750	3 750	5 000
Across full-disconnection [4)]	500	1 000	1 500	2 000	2 500
Across micro-disconnection [4)]	120	260	500	880	1 320
Across micro-interruption [2)]	–	–	–	–	–

Table 13.2 *(concluded)*

[1] Not applicable to class III situations.

[2] There are no electric strength requirements for micro-interruption, the satisfactory completion of the tests of clauses 15 to 17 inclusive are considered to be sufficient. Furthermore, for a control which has micro-disconnection in one position of its actuating means and micro-interruption in other positions, there are no requirements for electric strength for those positions corresponding to micro-interruption.

[3] For the tests of basic, supplementary and reinforced insulation all live parts are connected together and the maximum number of contacts are in the closed position.

[4] For the test of full-disconnection and micro-disconnection, contacts are opened automatically or manually and tested as soon after opening as possible to ensure that the contact separation and the supporting insulation are satisfactory.

In the case of temperature sensing controls it may be necessary to provide special samples specially calibrated to open between 15 °C and 25 °C to enable this test to be carried out at room temperature immediately after removal from the humidity cabinet.

[5] Special components which might render the test impractical such as electronic parts, neon lamps, coils or windings shall be disconnected at one pole or bridged as appropriate to the insulation being tested. Capacitors shall be bridged except for the tests for operational insulation when one pole is disconnected. Where such a proceeding is not practical, the tests of clauses 15 to 17 inclusive are considered to be sufficient.

[6] Any metal in contact with accessible metal is also regarded as accessible.

[7] For the tests of supplementary and reinforced insulation, the metal foil is applied in such a way that sealing compound, if any, is effectively tested.

[8] For controls incorporating reinforced insulation as well as double insulation, care is taken that the voltage applied to the reinforced insulation doe not over-stress the basic or the supplementary parts of the double insulation.

[9] For class I and class 0I controls and controls for class I situations, care is taken that adequate clearance is maintained between metal foil and accessible metal to avoid over-stressing insulation between live parts and earthed metal parts.

[10] The high-voltage transformer used for the test shall be so designed that when the output terminals are short-circuited after the output voltage has been adjusted to the test voltage the output current is at least 200 mA. The overcurrent relay shall not trip when the output current is less than 100 mA. Care is taken that the r.m.s. value of the test voltage is measured within ±3 %.

[11] to [13] inclusive see annex H.

[14] In some countries, other values are applicable.

[15] See annex H.

13.2.2 *When measuring reinforced or supplementary insulation to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.*

13.2.3 *The insulation is subjected to a voltage of substantially sine-wave form, having frequency of 50 Hz or 60 Hz. Voltage is applied for 1 min across the insulation or disconnection indicated in table 13.2 and has the value shown in the table.*

13.2.4 *Initially not more than half the prescribed voltage is applied, then it is raised rapidly to the full value. No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.*

13.3 For in-line cord and free-standing controls, after the tests of 13.1 or 13.2, as appropriate, the sample that was subjected to the tests of 12.3 shall be subjected to the tests of 13.3.1 to 13.3.4 inclusive.

Class III controls are not tested under these subclauses.

13.3.1 *A test voltage, d.c. for controls for d.c. only and a.c. for all other controls, is applied between any live part and*

- *accessible metal parts;*
- *metal foil with an area not exceeding 20 cm × 10 cm in contact with accessible surfaces of insulating material, connected together.*

  Measurements shall be done individually as well as collectively where surfaces are simultaneously accessible from one surface to another.

Where a surface is less than 20 cm × 10 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the control.

If the control is provided with a grounding pin or conductor, the grounding conductor is to be disconnected at the supply source.

13.3.2 *The test voltage is*

- *1,06 times rated voltage, or 1,06 times the upper limit of the rated voltage range, for controls for d.c. only, for single-phase controls and for three-phase controls which are also suitable for single-phase supply, if the rated voltage or the upper limit of the rated voltage range does not exceed 250 V;*
- *1,06 times rated voltage, or 1,06 times the upper limit of the rated voltage range, divided by $\sqrt{3}$, for other controls.*

13.3.3 *The leakage current is measured within 5 s after the application of the test voltage.*

13.3.4 *The maximum leakage current to accessible metal parts and metal foil shall not exceed the following values:*

- *for class 0, 0I, controls*	*0,5 mA,*
- *for class I controls*	*0,75 mA, and*
- *for class II controls*	*0,25 mA.*

In some countries, the values for controls using 250 V or less supply are as follows:

- for class 0, 0I and I controls	0,5 mA;
- for class II controls	0,25 mA.

14 Heating

14.1 Controls and their supporting surfaces shall not attain excessive temperatures in normal use.

14.1.1 *Compliance is checked by the test of 14.2 to 14.7 inclusive.*

In some countries, for some integrated and incorporated controls, the test of 14.2 to 14.7 inclusive is replaced by the tests of 17.7 and 17.8 conducted at the maximum declared operating value.

14.1.2 *During this test, the temperatures shall not exceed the values specified in table 14.1, and the controls shall not undergo any change so as to impair compliance with this standard and in particular with clauses 8, 13 and 20.*

14.2 *Terminals and terminations which are intended for the connection of external conductors, other than those for non-detachable cords using attachment methods M, Y or Z, shall be fitted with conductors of the intermediate cross-sectional area appropriate to the type of conductor and rating used in 10.1.4.*

14.2.1 *If attachment methods M, Y or Z are used then the cord declared or supplied shall be used for the test.*

14.2.2 *If a terminal is suitable for both flexible cords and for fixed conductors, then the appropriate flexible cord is used.*

14.2.3 *Terminals not intended for the connection of external conductors shall be fitted with conductors of the minimum cross-sectional area, as specified in 10.2.1, or with a special conductor if declared in 7.2.*

14.3 *In-line cord controls are stood or rested on a dull black painted plywood surface.*

14.3.1 *Independently mounted controls are mounted as in normal use.*

14.4 *Controls shall be connected to a supply having the most unfavourable voltage between 0,94 V_R and 1,06 V_R. Circuits which are not voltage sensitive may be connected to a lower voltage (but not less than 10 % of V_R and loaded such that the most unfavourable current between 0,94 and 1,06 times the rated current flows in the circuit).*

In some countries, the test is conducted at the voltages specified in 17.2.3.1 and 17.2.3.2.

14.4.1 *Circuits and contacts not intended for external loads shall be specified by the manufacturer.*

14.4.2 *Actuating members are placed in the most unfavourable position.*

14.4.3 *Contacts required to be closed initially for the purpose of this test are closed at the rated current and the rated voltage of the circuit.*

14.4.3.1 *For temperature sensing controls the temperature sensing element is raised or lowered to a temperature which differs from the measured operating temperature under the conditions of this clause·(5 ± 1) °C such that the contacts are then in the closed position.*

Where the whole control has been declared as the sensing element (see table 7.2, requirement 47) the heating test shall be conducted under the conditions of both 14.4.3.1 and 14.5.1.

14.4.3.2 *For all other sensing controls the sensing element shall be maintained such that the contacts are in the closed position, but are as near the point of opening as is practical.*

14.4.3.3 *It may be necessary to raise or lower, as appropriate, the value of the activating quantity beyond the operating value so as to cause operation and then to return the value of activating quantity to the required level.*

14.4.3.4 *For other automatic controls the most arduous operating sequence or segment of the operating sequence shall be selected.*

14.4.4 *If the control starts to operate during this test, the control is reset so that the contacts will remain closed.*

14.4.4.1 *If resetting to reclose the contacts is not practical, then the test is discontinued. A new operating value is determined and the test repeated using this new operating value.*

14.5 *Controls are tested in an appropriate heating and/or refrigerating apparatus such that the conditions in 14.5.1 and 14.5.2 are obtained.*

Except for controls submitted in or with appliances, the test shall be conducted in an environment protected from drafts. Natural convection is permitted.

14.5.1 *The temperature of the switch head is maintained between T_{max} and either (T_{max} + 5) °C or 1,05 times T_{max}, whichever is greater. The temperature of any mounting surface is maintained between $T_{s\ max}$ and either ($T_{s\ max}$ + 5) °C or 1,05 times $T_{s\ max}$ whichever is the greater if $T_{s\ max}$ is different from T_{max}.*

14.5.2 *In-line cord controls, independently mounted controls and those parts of integrated and incorporated controls which are accessible when the control is mounted as in normal use shall be in a room temperature in the range of 15 °C to 30 °C, the resulting measured temperature being corrected to a 25 °C reference value.*

14.6 *The temperatures specified for the switch head, the mounting surfaces and sensing element shall be attained in approximately 1 h.*

14.6.1 *The electrical and thermal conditions are maintained for 4 h, or for 1 h after steady state, whichever occurs first.*

14.6.2 *For controls designed for short-time or intermittent operation the resting time(s) declared in 7.2 item 34, shall be included in the 4 h.*

14.7 *The temperature of the medium in which the switch head is located, and the value of the activating quantity to which the sensing element is exposed, shall be measured as near as possible to the center of the space occupied by the samples and at a distance of approximately 50 mm from the control.*

14.7.1 *The temperature of the parts and surfaces indicated in table 14.1 shall be determined by means of fine wire thermocouples or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the part under test.*

14.7.2 *Thermocouples used for determining the temperature of supporting surfaces are attached to the back of small blackened discs of copper or brass, 15 mm in diameter and 1 mm thick, which are flush with the surface. So far as is possible, the control is positioned such that parts likely to attain the highest temperatures touch the discs.*

14.7.3 *In determining the temperature of actuating members and other handles, knobs, grips and the like, consideration is given to other parts which are gripped in normal use, and if of non-metallic material to parts in contact with hot metal.*

14.7.4 *The temperature of electrical insulation, other than that of windings, is determined on the surface of the insulation at places where failure could cause:*

- *a short circuit;*
- *a fire hazard;*
- *an adverse effect on the protection against electric shock;*
- *contact between live parts and accessible metal parts;*
- *bridging of insulation;*
- *reduction of creepage distances or clearances below the values specified in clause 20.*

Table 14.1

Parts	Maximum temperature permitted °C
Pins of appliance inlets and plug-in devices 1) :	
- for very hot conditions	155
- for hot conditions	120
- for cold conditions	65
Windings 8) 9) 10) 11) 13) and core laminations in contact therewith, if winding insulation is:	
- of class A material	100 [90]
- of class E material	115 [105]
- of class B material	120 [110]
- of class F material	140
- of class H material	165
Terminals and terminations for external conductors 1) 7)	85
Other terminals and terminations 1) 2)	85
Rubber or polyvinyl chloride insulation of conductors 1) :	
- if flexing occurs or is likely to occur	60
- if no flexing occurs or is likely to occur	75
- with temperature marking or temperature rating	value marked
Cord sheath used as supplementary insulation 12)	60
Rubber other than synthetic when used for gaskets or other parts, the deterioration of which could impair compliance with this standard:	
- when used as supplementary or as reinforced insulation	65
- in other cases	75
Materials used as insulation other than for wires 3) 5) 12):	
- impregnated or varnished textile, paper or press board	95
- laminates bonded with:	
melamine formaldehyde, phenol-formaldehyde or phenol-furfural resins	110 [200]
urea-formaldehyde resins	90 [175]
- mouldings of 3)	
phenol-formaldehyde, with cellulose fillers	110 [200]
phenol-formaldehyde, with mineral fillers	125 [225]
melamine-formaldehyde	100 [175]
urea-formaldehyde	90 [175]
polyester with glass fibre reinforcement	135
pure mica and tightly sintered ceramic material when such products are used as supplementary or reinforced insulation	425
other thermosetting materials and all thermo-plastic material 4)	–
All accessible surfaces except those of actuating members, handles, knobs, grips and the like	85

Table 14.1 *(continued)*

Parts	Maximum temperature permitted °C
Accessible surfaces of handles, knobs, grips and the like used for carrying and transporting the control:	
- of metal	55
- of porcelain or vitreous material	65
- of moulded material, rubber or wood	75
Accessible surface of actuating members, or of other handles, grips or the like which are held for short periods only:	
- of metal	60
- of porcelain or vitreous material	70
- of moulded material, rubber or wood	85
Wood in general	90
Supported painted plywood surface	85
Current-carrying parts made of copper or brass 1)	230
Current-carrying parts made of steel 1)	400
Other current-carrying parts 1) 6)	-

1) For these parts, the test of this clause is repeated after clause 17. In some countries this does not apply.

2) The temperature measured shall not exceed 85 °C unless a higher value has been declared by the manufacturer.

3) The values in square brackets apply to those parts of a material used for actuating members, handles, knobs, grips and the like and which are in contact with hot metal, but are not accessible.

4) The maximum permissible temperatures shall not exceed those which can be shown to be acceptable in service for these materials. The temperatures shall be recorded for the purposes of clause 21.

5) Where a metal part is in contact with a part made of insulating material it is assumed that the temperature of the insulating material at the point of contact is the same as the temperature of the metal part.

6) The maximum permissible temperature shall not exceed those which have been shown to be acceptable in service for these materials.

7) For controls submitted in or on equipment, only the temperatures of terminals for fixed conductors are verified, as such equipment are not usually delivered with external conductors. For equipment with other than terminals for fixed conductors, the temperature of the insulation of the external conductor is determined instead of the temperature of the terminals.

In some countries, the maximum temperature permitted is 75 °C. Higher temperatures are permitted if the control is marked with the required T rating for the external conductors.

8) The classification is in accordance with IEC 60085.

Examples of class A material are: impregnated cotton, silk, artificial silk and paper; enamels based on oleo- or polyamide resins.

Examples of class B material are: glass fibre, melamine and phenol formaldehyde resins.

Examples of class E material are:

- mouldings with cellulose fillers, cotton fabric laminates and paper laminates, bonded with melamine-formaldehyde, phenol-furfural resins;

Table 14.1 *(concluded)*

- cross-linked polyester resins, cellulose triacetate films, polyethylene terephthalate films;
- varnished polyethylene terephthalate textile bonded with oil modified alkyd resin varnish;
- enamels based on polyvinylformal, polyurethane or epoxy resins.

More extensive accelerated temperature tests and, in addition, compatibility testing is required for insulation systems of class B and higher temperature classes.

For totally enclosed motors using class A, E and B material, the temperatures may be increased by 5 °C. A totally enclosed motor is a motor so constructed that the circulation of the air between the inside and the outside of the case is prevented but not necessarily sufficiently enclosed to be called airtight.

[9] To allow for the fact that the temperature of windings of universal motors, relays, solenoids, etc., is usually below the average at the points accessible to thermo-couples, the figures without square brackets apply when the resistance method is used and those with square brackets apply when thermocouples are used. For the windings of vibrator coils and a.c. motors, the figures without square brackets apply in both cases.

[10] The value of the temperature rise of a copper winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1}\left(234{,}5 + t_1\right) - \left(t_2 - t_1\right)$$

where:

Δt is the temperature rise;

R_1 is the resistance at the beginning of the test;

R_2 is the resistance at the end of the test;

t_1 is the working ambient temperature at the beginning of the test, to be set at T_{max};

t_2 is the working ambient temperature at the end of the test;

At the beginning of the test, the windings are to be at T_{max}.

It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

The maximum temperature attained for the purposes of this clause is derived by adding the temperature rise to T_{max}.

[11] In some countries, temperature limits are not specified for small synchronous motors and the like. It is considered that if the electric strength requirements of clause 13 are still met after the tests of clause 17, then the insulation is adequate.

[12] The temperature values given, which are related to heat resistant properties of the material, may be exceeded where particular materials have been investigated and recognized as having special heat resistant properties.

[13] For small windings with a cross section, the minor dimension of which is no greater than 5 mm, the maximum temperature permitted when measured by the resistance method is:

Class	°C
A	105
E	120
B	130
F	155
H	180

15 Manufacturing deviation and drift

15.1 Those parts of controls providing a Type 2 action shall have adequate consistency of manufacture with regard to their declared operating value, operating time, or operating sequence.

In some countries, manufacturing deviation and drift are expressed as separate tolerances to the declared operating value. For some controls with Type 2 action, allowable values of manufacturing deviation and drift are specified. The consistency is then determined, using prescribed apparatus, by measurement of the operating value of the sample and comparison to the declared operating value.

15.2 *Compliance is checked by the appropriate tests of this clause.*

15.3 *For those controls which are completely or partially destroyed during their normal operation, the tests of the appropriate subclauses of clause 17 are deemed to be sufficient.*

15.4 *For those controls which are dependent on the method of mounting on, or incorporation in an equipment for their operation the manufacturing deviation and the drift shall be declared separately and be comparative values. The declared manufacturing deviation should be expressed as a bandwidth or spread (for example 10 K) and the drift by an alteration of value (for example ±10 K or +5 K, −10 K)*

15.5 *The consistency shall be determined as follows:*

15.5.1 *Test apparatus used shall be such that the control is mounted in the manner declared by the manufacturer.*

15.5.2 *For sensing controls the apparatus shall preferably be such that the normal operation of the control is used to control the apparatus.*

15.5.3 *However, because this test is made to determine comparative values rather than response values, the form of the apparatus is not critical. It should, however, simulate as nearly as is practicable the conditions of service.*

15.5.4 *The electrical conditions of the test shall normally be $V_{R\ max}$ and $I_{R\ max}$ unless different conditions have been declared in requirement 41 of table 7.2.*

However, the operation of the control shall be sensed by a suitable device with a sensing current not exceeding 0,05 A.

15.5.5 *For sensing controls the rate of change of activating quantity shall be any suitable value unless specific values have been declared in requirement 37 of table 7.2.*

15.5.6 *The appropriate operating value, operating time or operating sequence shall be recorded for each sample. No two samples shall differ from each other by an amount exceeding the declared manufacturing deviation.*

15.5.7 *The recorded values are also used as reference values for each sample, so that the repeat tests after the environmental tests of clause 16 and the endurance test of clause 17 will enable drift to be determined.*

15.6 *For those controls which are not dependent for their operation on the method of mounting on, or incorporation in, an equipment (for example timers, current sensing controls, voltage sensing controls, energy regulators or the drop-out current of electrically operated controls); the determination of consistency shall be as follows:*

15.6.1 *The manufacturing deviation, and/or the drift may be an absolute value. In this case a single declaration combining both the manufacturing deviation and the drift may be made.*

15.6.2 *The appropriate operating value, operating time or operating sequence shall be initially measured for all samples and be within the limits declared by the manufacturer.*

15.6.3 *Test apparatus shall be such as to simulate the most arduous conditions of normal use declared.*

15.6.4 *If a drift value has been declared separately in requirement 42 of table 7.2, the measured values for each sample shall be recorded as a reference value, so that the repeat tests after the environmental tests of clause 16 and the endurance tests of clause 17 will enable the drift to be determined.*

15.7 See annex J.

16 Environmental stress

16.1 Controls which are sensitive to the environmental stresses of temperature shall withstand the level of the appropriate stress likely to occur in transportation and storage.

16.1.1 *Compliance is checked by the appropriate tests of 16.2, carried out with the control being left in the same condition declared as a transportation condition. If no transportation condition is declared the control is tested with an actuating member or actuating means in the most unfavourable position.*

16.2 Environmental stress of temperature

16.2.1 *The effect of temperature is tested as follows:*

- *The entire control shall be maintained at a temperature of (10 ± 2) °C for a period of 24 h.*
- *The entire control shall then be maintained at a temperature of (60 ± 5) °C for a period of 4 h.*

In some countries, different values of temperature and time may apply.

16.2.2 *The control is not energized during either test.*

16.2.3 *After each test a control with an actuating member or actuating means shall be capable of being actuated to provide correctly the class of circuit disconnection declared, in so far as this can be determined without dismantling the control. This test is carried out at normal room temperature.*

The control is held at room temperature for 8 h prior to actuation.

16.2.4 *In addition, for controls with Type 2 actions, the appropriate test of clause 15 shall be repeated after each of the above tests. The value measured in these tests shall not differ from the value recorded in clause 15 for the same sample, by an amount greater than the drift declared in requirement 42 of table 7.2.*

17 Endurance

17.1 General requirements

17.1.1 Controls, including those submitted in or with an equipment, shall withstand the mechanical, electrical and thermal stresses that occur in normal use.

17.1.2 Controls with Type 2 actions shall operate such that any operating value, operating time or operating sequence does not change by an amount greater than the declared drift.

17.1.2.1 *Compliance with 17.1.1 and 17.1.2 is checked by the tests of 17.1.3 as indicated in 17.16.*

17.1.3 Test sequence and conditions

17.1.3.1 *In general, the sequence of tests is:*

- *an ageing test specified in 17.6 (This test applies only to those actions classified as Type 1.M or 2.M);*
- *an overvoltage test of automatic action at accelerated rate specified in 17.7. (In some countries this test is replaced by an overload test);*
- *a test of automatic action at accelerated rate specified in 17.8;*
- *a test of automatic action at slow rate specified in 17.9 (this test applies only to slow-make, slow-break automatic actions);*
- *an overvoltage test of manual action at accelerated speed specified in 17.10. (in some countries this test is replaced by an overload test);*
- *a test of manual action at slow speed specified in 17.11;*
- *a test of manual action at high speed specified in 17.12. (this test applies only to actions with more than one pole, and where polarity reversal occurs during the operation);*
- *a test of manual action at accelerated speed specified in 17.13.*

17.1.3.2 *The electrical, thermal and mechanical conditions of test shall in general be those specified in 17.2, 17.3 and 17.4. The general test requirements are given in 17.6 to 17.14 inclusive. The particular test requirements are given in the appropriate part 2.*

17.1.3.3 *Tests for a manual action forming part of an automatic action are normally specified in the subclause appropriate to the automatic action. If, however, tests are not specified, then 17.10 to 17.13 inclusive apply to such manual actions.*

17.1.3.4 After all the tests specified the samples shall meet the requirements of 17.14, unless otherwise specified in the appropriate part 2.

17.1.4 See annex H.

17.2 Electrical conditions for the tests

17.2.1 *Each circuit of the control shall be loaded according to the ratings declared by the manufacturer. Circuits and contacts which are not intended for external loads are operated with the designed load. Some changeover circuits may require testing separately for each part if such a manner has been declared by the manufacturer, particularly if the rating of one part of the changeover circuit depends upon the current carried by the other part.*

17.2.2 *In those countries which use an overvoltage test, the electrical loads to be used are those specified in table 17.2-1 at rated voltage* V_R*, with this voltage then being increased to 1,15* V_R *for the overvoltage test of 17.7 and 17.10.*

17.2.3 *In those countries which use an overload test, the conditions specified in tables 17.2-2 and 17.2-3 apply. The overload tests are performed on a single pole or throw at a time, with all other poles or throws at normal load.*

17.2.3.1 *In some countries using an overload test, test voltages* (V_T) *are:*

- *120 V for controls rated at any voltage between 110 V to 120 V*
- *240 V for controls rated at any voltage between 220 V to 240 V*
- *277 V for controls rated at any voltage between 254 V to 277 V*
- *480 V for controls rated at any voltage between 440 V to 480 V*
- *600 V for controls rated at any voltage between 550 V to 600 V.*

17.2.3.2 *If the rating of the control does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage.*

17.2.4 *When there is an earthed neutral system, the enclosure shall be connected through a 3 A cartridge fuse to the protective conductor of the circuit, and for other than an earthed neutral system, the enclosure shall be connected through such a fuse to the live pole least likely to break down to earth.*

17.2.5 *For Type 1.G or 2.G actions, or other off-load actions, auxiliary switches are used to simulate the intended operation during the test.*

Table 17.2-1 – Electrical conditions for the tests (this table applies in countries using an overvoltage test)

Type of circuit as classified in 6.2	**Operation**	**AC circuit**			**DC circuit**		
		V	**A**	**Power factor** (±0,05)[3]	**V**	**A**	**Time constant (±1 ms)**
Substantially resistive (classified 6.2.1)	Making and breaking	V_R	I_R	0,95	V_R	I_R	Non-inductive
Resistive or inductive (classified 6.2.2)	Making[1]	V_R	6,0 I_X or I_R if arithmetically the greater	0,6 0,95	V_R	2,5 I_X or I_R if arithmetically the greater	7,5
	Breaking	V_R	I_X or I_R if arithmetically the greater	0,95		I_X or I_R if arithmetically the greater	Non-inductive
Declared specific load (classified 6.2.3)	Making and breaking	V_R	As determined by load		V_R	As determined by load	
20 mA load (classified 6.2.4)	Making and breaking	V_R	20 mA	0,95	V_R	20 mA	Non-inductive
Declared motor load (classified 6.2.5)	Making and breaking	V_R	As declared		V_R	As declared	
Pilot duty load (classified 6.2.6)	Making[1]	V_R	10 VA/ V_R	0,35		2)	
	Breaking	V_R	VA/ V_R	0,95			

[1] The specified making conditions are maintained for a period between 50 ms and 100 ms, and are then reduced by an auxiliary switch to the specified breaking conditions. If during any test to this clause, contact break occurs within 2 s of contact make, the conditions specified for making are also used for breaking.

[2] These values are not applicable.

[3] Resistors and inductors are not connected in parallel except that if any air-core inductor is used, a resistor taking approximately 1 % of the current through the inductor is connected in parallel with it. Iron-core inductors may be used provided that the current has a substantially sine waveform. For three-phase tests three-core inductors are used.

Table 17.2-2 – Electrical conditions for the tests of 17.7 and 17.10 (this table applies in countries using an overload test)

Type of circuit	Operation	AC circuit			DC circuit	
		V	A	Power factor	V	A
Substantially resistive (classified 6.2.1)	Making and breaking	V_T	$1,5 I_R$	1,0	V_T	$1,5 I_R$
Inductive (non-motor)	Making and breaking	V_T	$1,5 I_X$	0,75-0,8	V_T	$1,5 I_X$
Declared motor load (classified 6.2.5)	Making and breaking	V_T	$6 I_m$ or as declared	0,4-0,5 or as declared	V_T	$10 I_m$ or as declared
Pilot duty load (classified 6.2.6)	Making	$1,1\ V_T$	11 VA/ V_T	0,35 maximum or as declared	As declared	
	Breaking	$1,1\ V_T$	$1,1$ VA/ V_T or as declared			

The following abbreviations are used:

V_R is the rated voltage, V_T is the test voltage (see 17.2.3.1). A circuit in which the closed-circuit voltage is 100-110 % of V_T is acceptable for the tests.

I_m is the rated current or motor load, I_R is the rated current for resistive load, I_X is the rated current for induction load.

NOTE – For test purposes a pilot duty load consists of an electromagnet representative of the magnet coil which is to be controlled. The normal current is that determined from the voltage and volt-ampere ratings of the electromagnet. The test current is the normal current and for an alternating current the power factor is to be 0,35 or less and the inrush current is to be 10 times the normal current. The test contactor is to be free to operate i.e., not blocked in either the open or the closed position.

An alternating-current pilot duty rating may be determined for a control which has been tested for controlling an alternating-current motor on the following basis:

- during the overload test the control was caused to make and break, for 50 cycles at a rate of 6 cycles per minute, a current having a value equivalent to six times the full-load motor current at a power factor of 0,5 or less, and
- the pilot duty inrush current rating (10 times the normal current rating) is to be not more than 67 % of the current value for the overload test described above.

For controls that may make a motor circuit under locked rotor conditions but that are never required to break the circuit under such conditions, the following applies

- for table 17.2-2:
  - a) 100 % V_T for a.c. and 0,5 V_T for d.c. for 1,5 rated current
  - b) 100 % V_T for locked-rotor current (make only)
- for table 17.2-3:

  100 % V_T for a.c. and 0,5 V_T for d.c.

A switch that is not intended primarily to make and break motor current under locked-rotor conditions, but which has a manual adjusting or regulating means that may cause it to be so used, shall comply with the requirements of 17.7 for a locked-rotor test.

For a switch intended for d.c. operation, the number of operations shall be five (5), conducted at intervals of 30 s and the device shall also comply with the requirements of a) above.

Table 17.2-3 – Electrical conditions for the tests of 17.8, 17.9, 17.11, 17.12 and 17.13 (this table applies in countries using an overload test)

		AC circuit			DC circuit	
Type of circuit	**Operation**	**V**	**A**	**Power factor**	**V**	**A**
Substantially resistive (classified 6.2.1)	Making and breaking	V_T	I_R	1	V_T	I_R
Inductive (non-motor)	Making and breaking	V_T	I_X	0,75-0,8	V_T	I_X
Declared motor load (classified 6.2.5)	Making and breaking	V_T	I_m or as determined by load	0,75-0,8 or as declared	V_T	I_m
Pilot duty load (classified 6.2.6)	Making	1,1 V_T	10 VA/ V_T	0.35 maximum or as declared	As declared	
	Breaking	1,1 V_T	VA/ $V_T$or as declared			

The following abbreviations are used:

V_R is the rated voltage, V_T is the test voltage (see 17.2.3.1).

I_m is the rated current for motor load, I_R is the rated current for resistive load, I_X is the rated current for induction load.

NOTE – For test purposes a pilot duty load consists of an electromagnet representative of the magnet coil which is to be controlled. The normal current is that determined from the voltage and volt-ampere ratings of the electromagnet. The test current is the normal current and for an alternating current the power factor is to be 0,35 or less and the inrush current is to be 10 times the normal current. The test contactor is to be free to operate i.e., not blocked in either the open or the closed position.

An alternating-current pilot duty rating may be determined for a control which has been tested for controlling an alternating-current motor on the following basis:

- during the overload test the control was caused to make and break, for 50 cycles at a rate of 6 cycles per minute, a current having a value equivalent to six times the full-load motor current at a power factor of 0,5 or less, and
- the pilot duty inrush current rating (10 times the normal current rating) is to be not more than 67 % of the current value for the overload test described above.

17.3 Thermal conditions for the tests

17.3.1 *For parts of the control other than any temperature sensing element, the following shall apply:*

- *those parts which are accessible when the control is mounted in a declared manner shall be exposed to normal room temperature (see 4.1);*
- *the mounting surface of the control shall be maintained between* $T_{s\ max}$, *and either* ($T_{s\ max}$ *+ 5) °C, or 1,05 times* $T_{s\ max}$, *whichever is greater;*
- *the remainder of the switch head shall be maintained between* T_{max} *and either* (T_{max} *+ 5) °C or 1,05 times* T_{max}, *whichever is greater. If* T_{min} *is less than 0 °C, additional tests shall be carried out with the switch head maintained between* T_{min} *and* (T_{min} *– 5) °C.*

17.3.2 *During the tests of 17.8 and 17.13, the temperatures of 17.3.1 are applied for the last 50 % of each test. For the first 50 % of each test the switch head is maintained at normal room temperature.*

Additional samples will be required if tests have to be performed at both temperatures (T_{max} *and* T_{min}).

17.4 Manual and mechanical conditions for the tests

17.4.1 *For all manual actions each cycle of actuation shall consist of a movement of the actuating member such that the control is successively moved into all positions appropriate to that action and then returned to its starting point; except that if a control has more than one intended OFF position, then each manual action shall be a movement from one OFF position to the next OFF position.*

17.4.2 *The speed of movement of the actuating member shall be:*

- *for slow speed:*
- *(9 ± 1)° per s for rotary actions*
- *(5 ± 0,5) mm/s for linear actions*
- *for high speed:*

  the actuating member shall be actuated by hand as fast as possible. If an actuating member is not supplied with a control then a suitable actuating member shall be fitted by the testing authority for the purpose of this test.
- *for accelerated speed*
- *(45 ± 5)° per s for rotary actions*
- *(25 ± 2,5) mm/s for linear actions*

17.4.3 *During the slow speed test of 17.4.2:*

care is taken that the test apparatus drives the actuating member positively, without significant backlash between the apparatus and the actuating member.

17.4.4 *During the accelerated speed test of 17.4.2:*

- *care is taken to determine that the test apparatus allows the actuating member to operate freely, so that it does not interfere with the normal action of the mechanism;*

- *for controls where the movement of the actuating member is limited:*
  - *there shall be a dwell period of not less than 2 s at each reversal of direction;*
  - *a torque (for rotary controls), or a force (for non-rotary controls) shall be applied at the extreme of each movement to verify the strength of the limiting end stops. The torque shall be either five times the normal actuating torque, or 1,0 Nm, whichever is the smaller, but with a minimum of 0,2 Nm. The force shall be either five times the normal actuating force, or 45 N, whichever is the smaller, but with a minimum of 9 N. If the normal actuating torque exceeds 1,0 Nm, or the normal actuating force exceeds 45 N, then the torque or force applied shall be the same as the normal actuating torque or force;*
- *for controls designed for a rotary actuation where the movement is not limited in either direction, three quarters of the number of cycles of actuation in each test shall be made in a clockwise direction, and one quarter in an anti-clockwise direction.*
- *for controls which are designed for actuation in one direction only, the test shall be in the designed direction, provided that it is not possible to rotate the actuating member in the reverse direction using the torques specified above.*

17.4.5 *Additional lubrication shall not be applied during these tests.*

17.5 Dielectric strength requirements

17.5.1 *After all the tests of this clause, the requirements of 13.2 shall apply, with the exception that the samples are not subjected to the humidity treatment before the application of the test voltage. The test voltages shall be 75 % of the corresponding test voltages shown in that subclause.*

In some countries the test voltage shall be that given in 13.2.

17.6 Ageing test

17.6.1 *During this test the sensing element shall be maintained at that value of the activating quantity determined and used in clause 14. Other parts shall be maintained as specified in 17.3. Controls are electrically loaded as specified in 17.2 for the appropriate breaking condition. The duration of the test is (100 + 0,02y) h where "y" is the value declared in 7.2. The test applies to controls with actions classified as Type 1.M or 2.M.*

17.6.2 *If during this test the action being tested operates, the value of the activating quantity is increased or decreased to cause reverse operation and then returned to a value differing by a quantity "x" from the original to enable the test to be resumed. This procedure may be repeated as many times as is necessary to complete the test, or until, when repeating the appropriate procedure of clause 15, the drift limits declared in 7.2 are exceeded. The value of "x" is given in the appropriate part 2.*

In some countries the ageing test does not apply.

17.7 Overvoltage (or in some countries overload) test of automatic action at accelerated rate

17.7.1 *The electrical conditions shall be those specified for overvoltage (or overload conditions) in 17.2.*

17.7.2 *The thermal conditions shall be those specified in 17.3.*

17.7.3 *The method and rate of operation is:*

- *for Type 1 actions the rate of operation and the method of operation shall be agreed between the testing authority and the manufacturer.*
- *for Type 2 actions the method of operation shall be that intended by design. For Type 2 sensing actions the rate of operation can be increased, either to the maximum cycling rated declared in 7.2, or so that the rates of change of activating quantity do not exceed α_2 and β_2 declared in the same subclause.*

Examples of such methods are the replacement of the capillary of a hydraulic system with an air pressure device or the fitting of a prime mover of a different speed.

17.7.4 *For Type 2 sensing actions, overshoot at each operation shall be between the values declared in 7.2.*

17.7.5 *It is permissible in the case of sensing actions to increase the rates of change of activating quantity, or for other Type 1 actions to override the prime mover between operations, provided that this does not significantly affect the results.*

17.7.6 *The number of automatic cycles for the test is either one tenth of the number declared in 7.2, or 200, whichever is the smaller.*

17.7.7 *During the test actuating members are placed in their most unfavourable position.*

In some countries where the overload test applies, the number of cycles is 50.

17.8 Test of automatic action at accelerated rate

17.8.1 *The electrical conditions shall be those specified in 17.2.*

17.8.2 *The thermal conditions shall be those specified in 17.3.*

17.8.3 *The method and rate of operation shall be as used during the test of 17.7.3.*

17.8.4 *The number of automatic cycles (except as shown below for slow-make, slow-break automatic actions) shall be that declared in 7.2 less the number of cycles actually made during the test of 17.7. During the test actuating members shall be placed in their most unfavourable position. During the test the failure of any component part of a Type 1 action which is not significant according to the requirements of the test, and which is considered to have failed as a result of the acceleration of the test, shall not be a cause of rejection, provided that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner, such that the total number of automatic cycles referred to in 7.2 can be completed.*

17.8.4.1 *For slow-make, slow-break automatic actions only 75 % of the number of automatic cycles referred to in 17.8.4 shall be carried out during this test. The remaining 25 % are carried out as specified in 17.9.*

In some countries the number of cycles is specified for Type 2 and some Type 1 actions

17.9 Test of automatic action at slow rate

17.9.1 *Slow-make, slow-break automatic actions shall be tested for the 25 % remainder of the number of automatic cycles specified in 17.8.*

17.9.2 *The electrical and thermal conditions shall be as specified in 17.2 and 17.3.*

17.9.3 *The method of operation is either by imposing a change of value of activating quantity on the sensing element, or by the prime mover. For sensing controls the rates of change of activating quantity shall be* a_1 *and* b_1 *as declared in 7.2. It is permissible, in the case of a sensing control to increase the rates of change of activating quantity, or for other automatic controls to override the prime mover, between operations, provided that this does not significantly affect the results. For sensing controls overshoot at each operation shall be between the values declared in 7.2. During this test for a Type 2 action continuous monitoring is essential to provide a record of operating value, overshoots or operating sequences.*

17.9.3.1 *Such monitoring is also recommended for other controls to determine consistency of testing.*

17.9.4 *If only the make or the break is a slow automatic action, then it may, by agreement between the testing authority and the manufacturer, be possible to accelerate the rest of the action, to which the details of 17.8 apply.*

17.10 Overvoltage (or in some countries, overload) test of manual action at accelerated speed

17.10.1 *The electrical conditions shall be those specified for overvoltage (or overload) in 17.2.*

17.10.2 *The thermal conditions shall be those specified in 17.3.*

17.10.3 *The method of operation shall be that specified in 17.4 for accelerated speed. The number of cycles of actuation shall be either one tenth of the number declared in 7.2 or 100, whichever is smaller. During the test, sensing elements are maintained at suitable values of activating quantity, and prime movers are so positioned as to ensure that actuation causes the appropriate operation.*

17.10.4 In some countries where the overload test applies, the number of cycles is 50

17.11 Test of manual action at slow speed

17.11.1 *The electrical conditions shall be those specified in 17.2.*

17.11.2 *The thermal conditions shall be those specified in 17.3.*

17.11.3 *The method of operation shall be that specified in 17.4 for slow speed.*

17.11.4 *The number of cycles of actuations shall be either one tenth of the number declared in 7.2 or 100, whichever is smaller. During the test, sensing elements are maintained at suitable values of activating quantity, and prime movers are so positioned, to ensure that actuation causes the appropriate operation.*

17.12 Test of manual action at high speed

This test applies only to actions which have more than one pole, and where polarity reversal occurs during the action.

17.12.1 *The electrical conditions are those specified in 17.2.*

17.12.2 *The thermal conditions are those specified in 17.3.*

17.12.3 *The method of operation is that specified in 17.4 for high speed.*

17.12.4 *The number of cycles of actuation is 100. During the tests, sensing elements are maintained at suitable values of activating quantity, and prime movers are so positioned as to ensure that actuation causes the appropriate operation.*

17.12.5 In some countries where the overload test applies, the number of cycles is 50.

17.13 Test of manual action at accelerated speed

17.13.1 *The electrical conditions are those specified in 17.2.*

17.13.2 *The thermal conditions are those specified in 17.3.*

17.13.3 *The method of operation is that specified in 17.4 for accelerated speed.*

17.13.4 *The number of cycles of actuation is that number declared in 7.2 less the number actually made during the tests of 17.10, 17.11 and 17.12. During the test, sensing elements are maintained at a suitable value of activating quantity, and prime movers are so positioned as to ensure that actuation causes the appropriate operation.*

17.13.5 *During the test, the failure of any component part of a Type 1 action other than a protective control which is not significant according to the requirements of the test, shall not be a cause of rejection providing that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner such that the total required number of cycles of actuation can be completed.*

17.14 Evaluation of compliance

After all the appropriate tests of 17.6 to 17.13 inclusive, modified as specified in the appropriate part 2, the control shall be deemed to comply if:

- *all actions function automatically and manually in the intended and declared manner within the meaning of this standard;*
- *the requirements of clause 14 with regard to those items designated by Note 1 of table 14.1, that is, terminals, current-carrying parts and supporting surfaces, are still met.* In some countries, this does not apply;

- *the requirements of clause 8, 17.5 and clause 20 are still met. For the tests of 17.5 and clause 20, controls for which special samples were submitted for clause 13, are tested at an appropriate condition to ensure that the contacts are open;*
- *for Type 2 actions, the appropriate test of clause 15 is repeated and the operating value, operating time or operating sequence shall still be within the value of drift, or within the values of combined drift and manufacturing deviation, whichever was declared;*
- *the circuit disconnection declared for each manual action can still be obtained;*
- *there is no evidence that any transient fault between live parts and earthed metal, accessible metal parts or actuating members has occurred.*

See also annex H.

17.15 Void

17.16 Test for particular purpose controls

The tests for particular purpose controls are specified in the appropriate Part 2s.

17.17 to **17.18** See annex J.

18 Mechanical strength

18.1 General requirements

18.1.1 Controls shall be so constructed as to withstand the mechanical stress that occurs in normal use.

18.1.2 Actuating members of class I and class II controls, and actuating members of controls for class I and class II equipment, shall either have adequate mechanical strength or be such that adequate protection against electric shock is maintained if the actuating member is broken.

18.1.3 Integrated controls and incorporated controls are not tested as in 18.2 as their impact resistance will be tested by the equipment standard.

18.1.4 *Compliance is checked by the tests of the appropriate subclauses 18.2 to 18.8 inclusive, carried out sequentially on one sample.*

18.1.5 *After the appropriate tests the control shall show no damage to impair compliance with this standard and in particular with clauses 8, 13, and 20. Insulating linings, barriers and the like shall not have worked loose.*

It shall still be possible to remove and to replace detachable and other external parts such as covers without such parts or their insulating linings breaking.

It shall still be possible to actuate a control to any position which is intended to provide full-disconnection and micro-disconnection.

In case of doubt, supplementary insulation or reinforced insulation is subject to an electric strength test as specified in clause 13.

Damage to the finish, small dents which do not reduce creepage distances or clearances below the values specified in clause 20, and small chips which do not adversely affect the protection against electric shock or moisture are neglected. Cracks not visible to the naked eye, and surface cracks in fibre reinforced mouldings and the like are ignored. If a decorative cover is backed by an inner cover, fracture of the decorative cover is neglected, if the inner cover withstands the test after removal of the decorative cover.

18.1.6 In some countries, if threads for the connection of metal conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be any sharp edges, not less than three nor more than five full threads in the metal and the construction of the device shall be such that a suitable conduit bushing can be properly attached.

18.1.6.1 In some countries, if threads for the connection of metal conduit are not tapped all the way through a hole in an enclosure wall, conduit hub or the like, there shall not be less than 3,5 full threads in the metal with a conduit stop, and a smooth well-rounded inlet hole having an internal diameter approximately the same as that of the corresponding size of rigid metal conduit, which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

18.1.6.2 In some countries, an enclosure threaded for support by rigid metal conduit shall provide at least five full threads for engaging the conduit.

Compliance with 18.1.6, 18.1.6.1 and 18.1.6.2 is checked by inspection.

18.1.6.3 In some countries, a conduit hub or nipple attached to the enclosure by swaging, staking or similar means shall withstand without pulling apart the following tests:

- a direct pull of 890 N for 5 min. For this test, the device is to be supported by a rigid conduit in the intended manner and is to support a suspended weight of 90,8 kg;
- the device is to be rigidly supported by means other than the conduit fittings. A bending force of 67,8 Nm is to be applied for 5 min to the conduit at right angles to its axis and the lever arm is measured from the wall of the enclosure in which the hub is located to the point of application of the bending force;
- a torque of 67,8 Nm is to be applied to the conduit for 5 min in a direction tending to tighten the connection and the lever arm is to be measured from the centre of the conduit.

Some distortion of the enclosure under test may result. Such distortion does not constitute a failure.

18.2 Impact resistance

18.2.1 *In-line cord, free-standing and independently mounted controls, except as provided in 18.4, are checked by applying blows to the sample by means of the apparatus in IEC 60068-2-75.*

18.2.2 *All surfaces which are accessible when the control is mounted as in normal use are tested with the apparatus.*

18.2.3 *The control is held in contact with a vertical sheet of plywood 8 mm thick and 175 mm square without any metallic back plate, the plywood being mounted on a rigid frame which is fixed to a solid wall of brick, concrete or the like.*

18.2.4 *Blows are applied to all accessible surfaces, including actuating members, at any angle, the test apparatus being calibrated to deliver an energy of (0,5 ± 0,04) Nm.*

18.2.4.1 *Foot actuated controls shall be subject to the same test, but using a test apparatus calibrated to deliver an energy of (1,0 ± 0,05) Nm.*

18.2.5 *For all such surfaces three blows are applied to every point that is likely to be weak.*

18.2.5.1 *Care must be taken that the results from one series of three blows does not influence subsequent series.*

18.2.5.2 *If there is a doubt whether a defect has been caused by the application of preceding blows, this defect is neglected and the group of three blows which led to the defect is applied to the same place of a new sample, which shall then withstand the test.*

18.2.6 *Signal lamps and their covers are only tested if they protrude from the enclosure by more than 10 mm or if their area exceeds 4 cm², unless they form part of an actuating member, in which case they shall be tested in the same manner as an actuating member.*

18.3 Void

18.4 Alternate compliance – Impact resistance

In some countries the minimum thicknesses of sheet metal or case metal shown in tables 18.4-1 and 18.4-2 are considered to meet the requirements of 18.2 and the tests specified are not required.

Table 18.4-1 – Minimum thickness of sheet metal for enclosures made of carbon steel or stainless steel

Without supporting frame 1)		**With supporting frame or equivalent reinforcing** 1)		**Minimum thickness** in inches (mm)	
Maximum width 2) in inches (cm)	**Maximum length** 3) in inches (cm)	**Maximum width** 2) in inches (cm)	**Maximum length** 3) in inches (cm)	**Uncoated**	**Metal coated**
4,0 (10,2)	Not limited	6,25 (15,9)	Not limited	0,020 4) (0,51)	0,023 4) (0,58)
4,75 (12,1)	5,75 (14,6)	6,75 (17,1)	8,25 (21,0)		
6,0 (15,2)	Not limited	9,5 (24,1)	Not limited	0,026 4) (0,66)	0,029 4) (0,74)
7,0 (17,8)	8,75 (22,2)	10,0 (25,4)	12,5 (31,8)		
8,0 (20,3)	Not limited	12,0 (30,5)	Not limited	0,032 (0,81)	0,034 (0,86)
9,0 (22,9)	11,5 (29,2)	13,0 (33,0)	16,0 (40,6)		
12,5 (31,8)	Not limited	19,5 (49,5)	Not limited	0,042 (1,07)	0,045 (1,14)
14,0 (35,6)	18,0 (45,7)	21,0 (53,3)	25,0 (63,5)		
18,0 (45,7)	Not limited	27,0 (68,6)	Not limited	0,053 (1,35)	0,056 (1,42)
20,0 (50,8)	25,0 (63,5)	29,0 (73,7)	36,0 (91,4)		
22,0 (55,9)	Not limited	33,0 (83,8)	Not limited	0,060 (1,52)	0,063 (1,60)
25,0 (63,5)	31,0 (78,7)	35,0 (88,9)	43,0 (109,2)		
25,0 (63,5)	Not limited	39,0 (99,1)	Not limited	0,067 (1,70)	0,070 (1,78)
29,0 (73,7)	36,0 (91,4)	41,0 (104,1)	51,0 (129,5)		
33,0 (83,8)	Not limited	51,0 (129,5)	Not limited	0,080 (2,03)	0,084 (2,13)
38,0 (96,5)	47,0 (119,4)	54,0 (137,2)	66.0 (167,6)		
42,0 (106,7)	Not limited	64,0 (162,6)	Not limited	0,093 (2,36)	0.097 (2.46)
47,0 (119,4)	59,0 (149,9)	68,0 (172,7)	84,0 (213,4)		
52,0 (132,1)	Not limited	80,0 (203,2)	Not limited	0,108 (2,74)	0,111 (2,82)
60,0 (152,4)	74,0 (188,0)	84,0 (213,4)	103,0 (261,6)		
63,0 (160,0)	Not limited	97,0 (246,4)	Not limited	0,123 (3,12)	0,126 (3,20)
73,0 (185,4)	90,0 (228,6)	103,0 (261,6)	127,0 (322,6)		

Table 18.4-1 *(concluded)*

[1] With reference to tables 18.4-1 and 18.4-2, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: a) single sheet with single formed flanges or formed edges, b) a single sheet that is corrugated or ribbed, c) an enclosure surface loosely attached to a frame, for example, with spring clips.

[2] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[3] "Not limited" applies only if the edge of the surface is flanged at least 0,5 in (12,7 mm) or fastened to adjacent surfaces not normally removed in use.

[4] Sheet metal for an enclosure intended for outdoor use shall be not less than 0,034 in (0,86 mm) thick if zinc coated and not less than 0,032 in (0,81 mm) thick if uncoated.

Table 18.4-2 Minimum thickness of sheet metal for enclosures of aluminium, copper or brass

Without supporting frame [1]		**With supporting frame or equivalent reinforcing [1]**		
Maximum width [2] in inches (cm)	**Maximum length [3] in inches (cm)**	**Maximum width [2] in inches (cm)**	**Maximum length [3] in inches (cm)**	**Maximum thickness in inches (cm)**
3,0 (7,6)	Not limited	7,0 (17,8)	Not limited	0,023[4] (0,58)
3,5 (8,9)	4,0 (10,2)	8,5 (21,6)	9,5 (24,1)	
4,0 (10,2)	Not limited	10,0 (25,4)	Not limited	0,029 (0,74)
5,0 (12,7)	6,0 (15,2)	10,5 (26,7)	13,5 (34,3)	
6,0 (15,2)	Not limited	14,0 (35,6)	Not limited	0,036 (0,91)
6,5 (16,5)	8,0 (20,3)	15,0 (38,1)	18,0 (45,7)	
8,0 (20,3)	Not limited	19,0 (48,3)	Not limited	0,045 (1,14)
9,5 (24,1)	11,5 (29,2)	21,0 (53,3)	25,0 (63,5)	
12,0 (30,5)	Not limited	28,0 (71,1)	Not limited	0,058 (1,47)
14,0 (35,6)	16,0 (40,6)	30,0 (76,2)	37,0 (94,0)	
18,0 (45,7)	Not limited	42,0 (106,7)	Not limited	0,075 (1,91)
20,0 (50,8)	25,0 (63,4)	45,0 (114,3)	55,0 (139,7)	
25,0 (63,5)	Not limited	60,0 (152,4)	Not limited	0,095 (2,41)
29,0 (73,7)	36,0 (91,4)	64,0 (162,6)	70,0 (198,1)	
37,0 (94,0)	Not limited	87,0 (221,0)	Not limited	0,122 (3,10)
42,0 (106,7)	53,0 (134,6)	93,0 (236,2)	114,0 (289,6)	
52,0 (132,1)	Not limited	123,0 (312,4)	Not limited	0,153 (3,89)
60,0 (152,4)	74,0 (188,0)	130,0 (330,2)	160,0 (406,4)	

[1] With reference to tables.18.4-1 and 18.4-2, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: a) single sheet with single formed flanges or formed edges, b) a single sheet that is corrugated or ribbed, c) an enclosure surface loosely attached to a frame, for example, with spring clips.

[2] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[3] "Not limited" applies only if the edge of the surface is flanged at least 0,5 in (12,7 mm) or fastened to adjacent surfaces not normally removed in use.

[4] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (raintight or rainproof) shall be not less than 0,029 in (0,74 mm) thick.

18.4.1 Cast metal shall be not less than 3 mm thick but not more than 6 mm thick at threaded holes for conduit; except that, other than at plain or threaded holes for conduit, die-cast metal may be not less than 1,6 mm thick for an area not greater than 150 cm², and having no dimension greater than 150 mm, and may be not less than 2,4 mm thick for larger areas.

18.5 Free-standing controls

18.5.1 *Free-standing controls shall be additionally checked by the test of 18.5.2 and 18.5.3 using the apparatus shown in figure 4.*

18.5.2 *Two metres of flexible cord of the lightest type used in 10.1.4 shall be connected to the input terminals and secured as intended. Controls intended for use with a flexible cored connected to the output terminals shall have 2 m of the lightest intended type similarly connected and arranged as shown in figure 4.*

The sample shall be stood or rested on the glass surface as shown and the cord shall be subjected to a steady pull gradually increasing up to, but not exceeding, that shown in table 11.7.2. If the sample moves, it is pulled off the glass surface as slowly as possible and allowed to fall onto the concrete backed hard wood base.

The height of the surface above the base is 0,5 m. The size of the hard wood and concrete base shall be sufficient for the control to remain on the base after falling.

The test is repeated three times.

18.5.3 *After the test, the sample shall be evaluated as in 18.1.5.*

18.6 In-line cord controls

18.6.1 *In-line cord controls other than free-standing controls shall be additionally tested in a tumbling barrel as shown in figure 5. The width of the barrel shall not be less than 200 mm, and shall be as wide as is necessary to ensure the uninterrupted fall of the control when fitted with the cords as required in 18.6.2.*

18.6.2 *Controls with non-detachable cords using attachment method X shall be fitted with the flexible cord or cords having the smallest cross-sectional area specified in 10.1.4 and a free length of approximately 50 mm. Terminal screws are tightened with two-thirds of the torque specified in 19.1. Controls with non-detachable cords using attachment methods M, Y or Z shall be tested with cord or cords declared or supplied, the cord or cords being cut so that a free length of about 50 mm projects from the control.*

18.6.3 *The sample falls from a height of 50 cm onto a steel plate, 3 mm thick, the number of falls being:*

- *1 000 if the mass of the sample without cord does not exceed 100 g;*
- *500 if the mass of the sample without cord exceeds 100 g, but does not exceed 200 g.*

18.6.4 *In-line cord controls with a mass exceeding 200 g are not tested in the tumbling barrel, but shall be subjected to the test of 18.5.*

18.6.5 *The barrel is turned at a rate of five revolutions per min, 10 falls per min thus taking place.*

18.6.6 *After this test, the control shall be evaluated as in 18.1.5. Special attention is paid to the connection of flexible cord or cords.*

18.7 Pull-cord actuated controls

18.7.1 *Pull-cord actuated controls shall be additionally tested as in 18.7.2 and 18.7.3.*

18.7.2 *The control shall be mounted as declared by the manufacturer, and the pull-cord shall be subjected to a force, applied without jerks, first for 1 min in the normal direction, and then for 1 min in the most unfavourable direction, but not exceeding 45° from the normal direction.*

18.7.3 *The values of the force are shown in table 18.7.*

Table 18.7

Rated current A	**Force** N	
	Normal direction	**Most unfavourable direction**
Up to and including 4	50	25
Over 4	100	50

18.7.4 *After this test the control shall be evaluated as in 18.1.5.*

18.8 Foot actuated controls

18.8.1 *Controls actuated by foot shall be additionally tested as follows:*

18.8.2 *The control is subjected to a force applied by means of a circular steel pressure plate with a diameter of 50 mm. The force is increased continuously from an initial value of about 250 N, up to 750 N, within 1 min, after which it is maintained at this value for 1 min.*

18.8.3 *The control is placed on a flat horizontal steel support with the appropriate flexible cord fitted. The force is applied three times with the sample placed in different positions, the most unfavourable positions being chosen.*

18.8.4 *After the test the control shall be evaluated as in 18.1.5.*

18.9 Actuating member and actuating means

18.9.1 *Controls supplied with, or intended to be fitted with actuating members shall be tested as follows:*

- *First an axial pull shall be applied for 1 min to try to pull off the actuating member.*
- *If the shape is such that it is not possible to apply an axial pull in normal use this first test does not apply.*
- *If the shape of the actuating member is such that an axial pull is unlikely to be applied in normal use, the force is 15 N.*
- *If the shape is such that an axial pull is likely to be applied, the force is 30 N.*

- *Secondly, an axial push of 30 N for 1 min is then applied to all actuating members.*

18.9.2 *If a control is intended to have an actuating member but is submitted for approval without, or is intended to have an easily removable actuating member then a pull and push of 30 N are applied to the actuating means.*

Sealing compound and the like, other than self hardening resins, is not deemed to be adequate to prevent loosening.

18.9.3 *During and after each of these tests the control shall show no damage, nor shall an actuating member have moved so as to impair compliance with this standard.*

19 Threaded parts and connections

19.1 Threaded parts moved during mounting or servicing

19.1.1 Threaded parts, electrical or otherwise which are likely to be operated while the control is being mounted or during servicing shall withstand the mechanical stresses occurring in normal use.

Threaded parts which are operated while the control is being mounted, or during servicing, include items such as terminal screws, cord anchorage screws, fixing and mounting screws, nuts, threaded rings and cover plate screws.

19.1.2 Such parts shall be easily replaceable if completely removed.

Constructions which restrict the complete removal of a threaded part are deemed to meet this requirement

19.1.3 Such threaded parts shall have a metric ISO thread or a thread of equivalent effectiveness.

Provisionally SI, BA and Unified threads are deemed to be of equivalent effectiveness to a metric ISO thread. A test for equivalent effectiveness is under consideration. Pending agreement to a test, all torque values for threads other than ISO, BA, SI or Unified shall be increased by 20%.

19.1.4 If such a threaded part is a screw and if it generates a thread in another part, it shall not be of the thread cutting type. It may be of the thread forming (swaging) type. There is no requirement for the type of thread so produced.

19.1.5 Such screws may be of the space threaded type, (sheet metal) if they are provided with a suitable means to prevent loosening.

Suitable means to prevent loosening of space threaded screws include a spring nut, or other component of similar resilience, or a thread of resilient material.

19.1.6 Such threaded parts shall not be of non-metallic material if their replacement by a dimensionally similar metal screw could impair compliance with clause 13 or 20.

19.1.7 Such screws shall not be of metal which is soft or liable to creep such as zinc or aluminum.

This requirement is not applicable to parts used either as a cover to limit access to setting means, or as setting means such as flow or pressure adjusters in gas controls.

19.1.8 Such screws operating in a thread of non-metallic material shall be such that the correct introduction of the screw into its counterpart shall be ensured.

The requirement for the correct introduction of a metal screw into a thread of non-metallic material may be met if the introduction of the screw in a slanting manner is prevented, for example, by guiding the screw or part to be fixed by a recess in the female thread, or by the use of a screw with the leading thread removed.

19.1.9 Such threaded parts, when used for in-line cord controls, if they are transmitting contact pressure and if they have a nominal diameter less than 3 mm, shall screw into metal. If they are of non-metallic material they shall have a nominal diameter of at least 3 mm, and shall not be used for any electrical connection.

19.1.10 *Compliance with 19.1.1 to 19.1.9 inclusive is checked by inspection and by the test of 19.1.11 to 19.1.15, inclusive.*

19.1.11 *Threaded parts are tightened and loosened:*

- *10 times if one of the threaded parts is of non-metallic material, or*
- *five times if both parts are of metallic material.*

19.1.12 *Screws in engagement with a thread of non-metallic material are completely removed and reinserted each time. When testing terminal screws and nuts, a conductor of the largest cross-sectional area used in 10.1.4 or of the minimum cross-sectional area specified in 10.2.1 is placed in the terminal.*

19.1.13 *The shape of the screwdriver should suit the head of the screw to be tested.*

19.1.14 *The conductor is moved each time the threaded part is loosened. During the test no damage impairing the further use of the threaded parts shall occur, such as breakage of screws or damage to the slot head or washers.*

19.1.15 *The test is made by means of a suitable test screwdriver, spanner or key, applying a torque, without jerks, as shown in table 19.1.*

Table 19.1

Nominal diameter of thread mm	**Torque** Nm		
	I	**II**	**III**
Up to and including 1,7	0,1	0,2	0,2
Over 1,7 up to and including 2,2	0,15	0,3	0,3
Over 2,2 up to and including 2,8	0,2	0,4	0,4
Over 2,8 up to and including 3,0	0,25	0,5	0,5
Over 3,0 up to and including 3,2	0,3	0,6	0,6
Over 3,2 up to and including 3,6	0,4	0,8	0,6
Over 3,6 up to and including 4,1	0,7	1,2	0,6
Over 4,1 up to and including 4,7	0,8	1,8	0,9
Over 4,7 up to and including 5,3 [1]	0,8	2,0	1,0
Over 5,3 [1]	–	2,5	1,25

Table 19.1 *(concluded)*

Use column I – for metal screws without heads if the screw when tightened does not protrude from the hole, or if the screwdriver access is limited to the major diameter of the screw.

Use column II – for other metal screws and for nuts:

- with a cylindrical head and a socket for a special purpose tool, the socket having a cross-corner dimension exceeding the overall thread diameter;
- with a head having a slot or slots, the length of which exceeds 1,5 times the overall thread diameter.

– for screws of non-metallic material having a hexagonal head with the dimension across flats exceeding the overall thread diameter.

Use column III – for other screws of non-metallic material

[1] Nuts and threaded rings of greater than 4,7 mm diameter which are used for single bush mounting are tested with a torque of 1,8 Nm.

19.2 Current-carrying connections

19.2.1 Current-carrying connections which are not disturbed during mounting or servicing and the efficiency or security of which is maintained by the pressure of a screw, threaded part, rivet or the like shall withstand the mechanical, thermal and electrical stresses occurring in normal use.

19.2.2 Such current-carrying connections which are also subject to torsion in normal use, (that is, having parts integral with or connected rigidly to screw terminals etc.) shall be locked against any movement which could impair compliance with clauses 13 or 20.

The requirement regarding being locked against movement does not imply that the current-carrying connection shall be so designed that rotation or displacement is prevented, provided that any movement is appropriately limited and does not bring about non-compliance with this standard.

Connections made with one screw, rivet or the like are sufficient if the parts are themselves prevented from making such movement by mechanical interaction between parts or by the provision of spring washers or the like

Connections made with one rivet with a non-circular or notched shank corresponding to appropriately shaped holes in the current-carrying parts are considered to meet this requirement. Connections made with two or more screws or rivets also meet this requirement.

Sealing compound may be used if the parts so sealed are not subjected to stress during normal use.

19.2.3 Such current-carrying connections shall be so designed that contact pressure is not transmitted through non-metallic material other than ceramic or other non-metallic material having characteristics no less suitable, unless there is sufficient resilience in the corresponding metal parts to compensate for any shrinkage or distortion of the non-metallic material.

The suitability of non-metallic material is considered with respect to the stability of the dimensions within the temperature range applicable to the control.

19.2.4 Such current-carrying connections shall not make use of space threaded screws, unless the screws clamp the current-carrying parts directly in contact with each other, and are provided with a suitable means of locking.

19.2.4.1 Space threaded screws may be used to provide earthing continuity if at least two such screws are used for each connection.

In some countries, to provide earthing continuity (bonding), the use of one screw is permitted if at least two full threads are engaged. If two screws are used, each screw shall engage at least one full thread.

19.2.5 Such current-carrying connections may make use of thread cutting screws if these produce a full-form standard machine screw thread.

19.2.5.1 Thread cutting screws may be used to provide earthing continuity if at least two such screws are used for each connection.

In some countries, to provide earthing continuity (bonding), the use of one screw is permitted if at least two full threads are engaged. If two screws are used, each screw shall engage at least one full thread.

19.2.6 Such current-carrying connections, whose parts rely on pressure for their correct function, shall have resistance to corrosion over the area of contact not inferior to that of brass. This requirement does not apply to parts whose essential characteristics may be adversely affected by plating such as bimetallic blades, which if not plated shall be clamped into contact with parts which have adequate resistance to corrosion. Suitable corrosion resistance may be achieved by plating or a similar process.

19.2.7 *Compliance with 19.2.1 to 19.2.6 inclusive is checked by inspection. In addition, compliance with 19.2.3 and 19.2.6 is checked by an inspection of the metallic resilient parts after the tests of clause 17 have been completed.*

20 Creepage distances, clearances and distances through solid insulation

Controls shall be constructed so that the clearances, creepage distances and distances through solid insulation are adequate to withstand the electrical stresses that can be expected.

Printed wiring boards conforming with all of the requirements for type B coating as specified in IEC 60664-3 shall comply with the minimum requirements of 20.3 for solid insulation. No creepage or clearance dimensions apply to conductor dimensions under the type B coating. See also annex Q.

Creepage distances and clearances between terminals for the connection of external conductors shall be not less than 2 mm, or the specified limit, whichever is the highest. This requirement does not apply to such terminals if they are only used for factory attachment of conductors or if they are used for connection in extra-low voltage circuits.

Compliance is checked by inspection, by measurement and by the tests of this clause.

NOTE 1 – The requirements and tests are based on IEC 60664-1 from which further information can be obtained.

NOTE 2 – A creepage distance cannot be less than the associated clearance. The shortest creepage distance possible is equal to the required clearance.

NOTE 3 – The manufacturer should note that the tabulated values of this clause are absolute minimum values that must be maintained for all manufacturing conditions and through the lifetime of the equipment.

NOTE 4 – See annex S for guidance.

In the US, other methods of evaluating creepage distances and clearances are optional.

20.1 Clearances

Clearances shall not be less than the values shown in table 20.2 for case A, taking into account the pollution degree and the rated impulse voltage required to serve the overvoltage categories of table 20.1, except that, for basic and operational insulation, smaller distances may be used if the control meets the impulse withstand test of 20.1.12 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion or by movement of the parts (e.g. during operation or during assembly), but in no case shall the clearances be less than the values for case B.

Compliance is checked by inspection, by measurement and, if necessary, by the test of 20.1.12.

NOTE 1 – Controls normally are expected to comply with the requirements for the overvoltage category of equipment in which they are used unless special circumstances determine other categories to be appropriate. Annex L provides guidance.

NOTE 2 – Controls which are constructed in accordance with the minimum dimensions of table 20.2, for case A, need not be subjected to the impulse test of 20.1.12. For further information on case A and case B, see IEC 60664-1, clauses 3.1.2.1 and 3.1.2.2.

Detachable parts are removed. Clearances are measured with movable parts and parts such as hexagon nuts which can be assembled in different orientations placed in the most unfavourable position.

A force is applied to bare conductors and accessible surfaces in order to attempt to reduce clearances when making the measurement.

The force is: 2 N for bare conductors;
30 N for accessible surfaces.

The force is applied by means of the test finger of figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE – Clearances are measured as specified in annex B.

Table 20.1 – Rated impulse voltage for equipment energized directly from the supply mains (from IEC 60664-1, table 1)

Nominal voltage of the supply based on IEC 60038 1), 4) **V**		**Voltage line-to-neutral derived from nominal voltages a.c. or d.c. up to and including** **V**	**Rated impulse voltage required according to overvoltage category 3)** **V**			
Three-phase four-wire systems 1)	**Single-phase2) systems**		**I**	**II**	**III**	**IV**
		50	330	500	800	1 500
		100	500	800	1 500	2 500
	120/240	150	800	1 500	2 500	4 000
230/400 277/480		300	1 500	2 500	4 000	6 000
400/690		600	2 500	4 000	6 000	8 000

Table 20.1 *(concluded)*

[1] The first value listed is the line-to-neutral or the line-to-earth voltage and the second value listed is the line-to-line voltage.

[2] See annex K for other supply systems (e.g. note that some three-phase, three-wire systems require higher rated impulse voltage than three-phase four-wire systems of similar voltage).

[3] See annex L for an explanation of overvoltage categories. Overvoltage category may be specified in a part 2.

[4] For controls capable of generating an overvoltage at the control terminals, for example switching devices, the rated impulse voltage implies that the control shall not generate overvoltage in excess of this value when used in accordance with the relevant standard and instructions of the manufacturer.

Table 20.2 – Clearances for insulation co-ordination (from IEC 60664-1, table 2)

Rated impulse voltage from table 20.1[1] kV	Clearances in air up to 2 000 m above sea level mm							
	Case A				Case B (impulse test required – see 20.1.12)			
	Pollution degree [2]				Pollution degree [2]			
	1	2	3	4	1	2	3	4
0,33	0,01	0,20	0,8		0,01	0,2	0,8	1,6
0,50	0,04				0,04			
0,80	0,10			1,6	0,1			
1,5	0,5	0,5			0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3

[1] For operational insulation, the rated impulse voltage is derived from the value in column 3 of table 20.1 which covers the measured voltage across the clearance, unless otherwise declared and justified by the manufacturer.

[2] An explanation of pollution degree is given in annex N.

[3] For altitudes of more than 2 000 m above sea level, the values for clearances shall be multiplied with the correction factor specified in IEC 60664-1, table A.2.

NOTE – For small values of clearances, the uniformity of the electric field can deteriorate in the presence of pollution, making it necessary to increase the clearance values above the values of case B.

20.1.1 The clearances of basic insulation shall be sufficient to withstand the overvoltages that can be expected in use, taking into account the rated impulse voltage. The values of table 20.2, case A apply except as permitted by 20.1.7.

Compliance is checked by measurement.

20.1.2 For operational insulation, table 20.2, case A applies

- except as permitted by 20.1.7;

or

- except that clearances for electronic controls are not specified if the requirements of H.27.1.3 are met with the clearances short-circuited.

20.1.3 *Compliance with 20.1 is checked by measurement using the methods of measurement as given in annex B and figure 17.*

20.1.3.1 *For controls provided with an equipment inlet or socket-outlet, the measurements are made twice, once with an appropriate connector or plug inserted, and once without a connector or plug inserted.*

20.1.3.2 *For terminals intended for the connection of external conductors, the measurements of such terminals are made twice, once with conductors of the largest cross-sectional area used in 10.1.4 fitted, and once without conductors fitted.*

20.1.3.3 *For terminals intended for the connection of internal conductors, the measurements of such terminals are made twice, once with conductors of the minimum cross-sectional area used in 10.2.1 fitted, and once without conductors fitted.*

20.1.4 *Distances through slots or openings in surfaces of insulating material are measured to metal foil in contact with the surface. The foil is pushed into corners and the like by means of the standard test finger shown in figure 2, but is not pressed into openings.*

20.1.5 *The standard test finger is applied to apertures as specified in 8.1, the distance through insulation between live parts and the metal foil shall then not be reduced below the values specified.*

20.1.6 *If necessary, a force is applied to any point on bare live parts which are accessible before the control is mounted, and to the outside of surfaces which are accessible after the control is mounted, in an endeavour to reduce the creepage distances, clearances and distances through insulation while taking the measurements.*

20.1.6.1 *The force is applied by means of the standard test finger and has a value of:*

- *2 N for bare live parts;*
- *30 N for accessible surfaces.*

Compliance is checked by measurement and by test if necessary.

When testing operational insulation, the impulse voltage is applied across the clearance.

NOTE – When carrying out the impulse test, it may be necessary to disconnect parts or components of the control.

20.1.7 For basic and operational insulation, smaller distances may be permitted if the control meets the impulse withstand test of 20.1.12 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion, by movement of the parts, or during assembly, but in no case shall the clearances be less than the values for case B.

Compliance is checked by the test of 20.1.12.

20.1.7.1 For micro-disconnection and interruption, there is no specified minimum distance for the clearance between the contacts. For other parts separated by the action of the contacts, clearances may be smaller than those of table 20.2, but shall not be less than the distance between the contacts.

20.1.7.2 For full disconnection, the values specified in table 20.2, case A apply to parts separated by the switching element including the contacts, when the contacts are in the fully open position.

20.1.8 Clearances of supplementary insulation shall be not less than those specified for basic insulation in table 20.2, case A.

Compliance is checked by measurement.

20.1.9 Clearances of reinforced insulation shall be not less than those in table 20.2, case A but using the next higher step for rated impulse voltage as a reference.

NOTE – For double insulation, where there is no intermediate conductive part between the basic insulation and supplementary insulation, clearances are measured between live parts and the accessible surface or accessible metal parts. The insulation system is treated as reinforced insulation.

Compliance is checked by measurement.

20.1.10 For controls or portions of controls supplied from a transformer with double insulation, clearances of operational insulation and basic insulation on the secondary side are based on the secondary voltage of the transformer which is used as the nominal voltage of table 20.1.

NOTE – The use of a transformer with separate windings alone does not allow a change of overvoltage category.

In the case of supply voltages derived from transformers without separate windings, the rated impulse voltage shall be determined from table 20.1 based on the primary voltage for step-down transformers, and based on the maximum measured r.m.s. value of the secondary voltage for step-up transformers.

NOTE – Part 2s may specify alternative criteria for some situations, e.g. high voltage ignition sources.

Table 2 of IEC 60664-1 gives clearance dimensions for higher impulse withstand voltages.

Compliance is checked by measurement or test if necessary.

20.1.11 For circuits having extra-low voltage which are derived from the supply by means of protective impedance, clearances of operational insulation are determined from table 20.1 based on the maximum measured value of the working voltage in the extra-low voltage circuit.

20.1.12 The impulse voltage test, when required, is applied in accordance with 4.1.1.2.1 of IEC 60664-1.

NOTE 1 – Part 2s may specify environmental test conditions.

The impulse voltage is applied between live parts and metal parts separated by basic or operational insulation.

NOTE 2 – In the case of operational insulation, it may be necessary to disconnect parts or components of the control.

20.2 Creepage distances

20.2.1 Controls shall be constructed so that creepage distances for basic insulation are not less than those specified in table 20.3 for the rated voltage, taking into account the material group and the pollution degree.

Creepage distances are not specified for electronic controls if the requirements of H.27.1.3 are met with the creepage distance short-circuited.

Compliance is checked by inspection and measurement.

Detachable parts are removed. Creepage distances are measured with movable parts and parts which can be assembled in different orientations placed in the most unfavourable position.

A force is applied to bare conductors and accessible surfaces in order to attempt to reduce creepage distances when making the measurement.

The force is: 2 N for bare conductors;
30 N for accessible surfaces.

The force is applied by means of the test finger of figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE – Creepage distances are measured as specified in annex B.

20.2.2 Controls shall be constructed so that creepage distances for operational insulation are not less than those specified in table 20.4 for working voltage, taking into account the material group and the pollution degree.

NOTE – Part 2s may specify alternative criteria for some situations, e.g. high voltage ignition sources.

Compliance is checked by inspection and measurement.

Detachable parts are removed. Creepage distances are measured with movable parts and parts which can be assembled in different orientations placed in the most unfavourable position.

A force is applied to bare conductors and accessible surfaces in order to attempt to reduce creepage distances when making the measurement.

The force is: 2 N for bare conductors;
30 N for accessible surfaces.

The force is applied by means of the test finger of figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE 1 – Creepage distances are measured as specified in annex B.

NOTE 2 – The relationship between material group and proof tracking index (PTI) values is found in 6.13.

The PTI values refer to values obtained in accordance with IEC 60112, and tested with solution A.

Materials, the PTI values of which have previously been found to comply with these material groups, are acceptable without further testing.

NOTE 3 – For glass, ceramics, or other inorganic insulating materials which do not track, creepage distances need not be greater than their associated clearance for the purpose of insulation co-ordination.

Table 20.3 – Minimum creepage distances for basic insulation

Rated voltage up to and including V	Creepage distances [1] mm									
	Pollution degree									
	1	2			3			4		
		Material group			Material group			Material group		
		I	II	III[2]	I	II	III[2]	I	II	III[2]
50	0,2	0,6	0,9	1,2	1,5	1,7	1,9	2,0	2,5	3,2
125	0,3	0,8	1,1	1,5	1,9	2,1	2,4	2,5	3,2	4,0
250	0,6	1,3	1,8	2,5	3,2	3,6	4,0	5,0	6,3	8,0
400	1,0	2,0	2,8	4,0	5,0	5,6	6,3	8,0	10,0	12,5
500	1,3	2,5	3,6	5,0	6,3	7,1	8,0	10,0	12,5	16,0
630	1,8	3,2	4,5	6,3	8,0	9,0	10,0	12,5	16,0	20,0
800	2,4	4,0	5,6	8,0	10,0	11,0	12,5	16,0	20,0	25,0

[1] Lacquered conductors of windings are considered to be bare conductors but creepage distances are not required to be larger than the associated clearance specified in table 20.2.

[2] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in pollution degree 4.

Compliance is checked by measurement.

Table 20.4 – Minimum creepage distances for operational insulation

Working voltage r.m.s. [3] V	Creepage distances [2] mm											
	Pollution degree											
	Printed wiring material[1] Pollution degree		1	2			3			4		
				Material group			Material group			Material group		
	1[4]	2[5]		I	II	III	I	II	III[6]	I	II	III[6]
10	0,025	0,04	0,08	0,40	0,40	0,40	1	1	1	1,6	1,6	1,6
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05	1,6	1,6	1,6
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25	1,7	1,7	1,7
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
160	0.25	0,4	0.32	0.8	1,1	1,6	2	2,2	2,5	3,2	4	5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	21
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25

Table 20.4 *(concluded)*

[1] When printed circuit boards are coated in accordance with annex P or clause Q.1 of annex Q and the coating has a PTI of at least 175, the values specified for pollution degree 1 are permitted. The PTI shall be measured in accordance with IEC 60112.

[2] For glass, ceramics and other inorganic materials which do not track, creepage distances need not be greater than their associated clearance.

[3] For higher working voltages, the values of table 4 of IEC 60664-1 apply.

[4] Material groups I, II, IIIa and IIIb.

[5] Material groups I, II and IIIa.

[6] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in pollution degree 4.

Compliance is checked by inspection.

20.2.3 Creepage distances of supplementary insulation shall be not less than those appropriate for basic insulation taking into account the material group and the pollution degree.

Compliance is checked by inspection and measurement.

20.2.4 Creepage distances of reinforced insulation shall be not less than double those appropriate for basic insulation, taking into account the material group and the pollution degree.

Compliance is checked by inspection and measurement.

20.3 Solid insulation

Solid insulation shall be capable of durably withstanding electrical and mechanical stresses as well as thermal and environmental influences which may occur during the anticipated life of the equipment.

20.3.1 There is no dimensional requirement for the thickness of basic or operational insulation.

There is no dimensional requirement for the thickness of supplementary or reinforced insulation which is not accessible and is not mica or similar scaling material and if:

- the maximum temperature determined during the tests of clause 14 does not exceed the value specified in table 14.1;
- and the insulation, after having been conditioned 168 h in an oven maintained at a temperature equal to 25 K in excess of the maximum temperature determined during the tests of clause 14, withstands the electric strength test of 13.2, this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

20.3.2 For working voltages up to and including 300 V, solid insulation serving as supplementary insulation or as reinforced insulation which is accessible shall have a minimum thickness of 0,7 mm, except that no thickness dimension is required if:

- for supplementary insulation, the insulation consists of at least two layers, provided that each of the layers withstands the electric strength test of 13.2;
- for reinforced insulation, the insulation consists of at least three layers, provided that any two layers together withstand the electric strength test of 13.2;

- and the maximum temperature determined during the tests of clause 14 does not exceed the value specified in table 14.1;
- and the insulation, after having been conditioned 168 h in an oven maintained at a temperature equal to 25 K in excess of the maximum temperature determined during the tests of clause 14, withstands the electric strength test of 13.2, this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

Compliance is checked by inspection and by test.

For optocouplers, the conditioning procedure is carried out at a temperature of 25 K in excess of the maximum temperature measured on the optocoupler during the tests of clauses 14 or 27, the optocoupler being operated under the most unfavourable conditions which occur during these tests.

21 Resistance to heat, fire and tracking

21.1 General requirements

All non-metallic parts of a control shall be resistant to heat, fire and tracking.

Compliance is checked by the tests of 21.2, except that independently mounted controls are checked by the tests of 21.3.

In the United States, compliance is checked by the procedure given in annex D.

21.2 Integrated, incorporated and in-line cord controls

The following test sequences shall be conducted as appropriate to the position of the non-metallic part and the declared category.

For guidance concerning categories, see annex F.

21.2.1 *For parts which are accessible when the control is mounted in its manner of intended use, and the deterioration of which may result in the control becoming unsafe:*

- *the ball pressure test of 21.2.5;*

followed by

- *either the horizontal burning test of clause G.1 of annex G;*
- *or, (in the absence of the special test specimens as required by that clause, or in the absence of relevant evidence that the material withstands the test, or if the special test specimens fail the test), the glow-wire test of clause G.2 of annex G carried out at 550 °C.*

21.2.2 *For parts which retain in position current-carrying parts other than electrical connections:*

- *the ball pressure test of 21.2.6;*

followed by

- *either the horizontal burning test of clause G.1 of annex G;*
- *or (in the absence of the special test specimens as required by that clause, or in the absence of relevant evidence that the material withstands the test, or if the special test specimens fail the test), the glow-wire test of clause G.2 of annex G carried out at 550 °C.*

21.2.3 *For parts which maintain or retain in position electrical connections, the tests shall be as indicated for the declared category of the control:*

Category A

- *the ball pressure test of 21.2.6;*

followed by

- *either the horizontal burning test of clause G.1 of annex G;*
- *or (in the absence of the special test specimens as required by that clause, or in the absence of relevant evidence that the material withstands the test, or if the special test specimens fail the test), the glow-wire test of clause G.2 of annex G carried out at 550 °C.*

Category B

- *the ball pressure test of 21.2.6;*

followed by

- *either the horizontal burning test of clause G.1 of annex G;*
- *or (in the absence of the special test specimens as required by that clause, or in the absence of relevant evidence that the material withstands the test, or if the special test specimens fail the test), the glow-wire test of clause G.2 of annex G carried out at 550 °C.*

In addition, all other non-metallic parts forming part of the control and situated within 50 mm of the part supporting current-carrying parts, shall meet the requirements of the Needle-flame test of clause G.3 of annex G.

Category C

- *the ball pressure test of 21.2.6 followed by the glow-wire test of clause G.2 of annex G carried out at 750 °C.*

Category D

- *the ball pressure test of 21.2.6 followed by the glow-wire test of clause G2 of annex G carried out at 850 °C.*

21.2.4 *For all other parts, (except decorative trim, knobs and other small parts too small to be subjected to the glow wire test and, therefore, unlikely to be ignited, for which no test is required):*

- *either the horizontal burning test of clause G.1 of annex G;*
- *or (in the absence of the special test specimens as required by that clause, or in the absence of relevant evidence that the material withstands the test, or if the special test specimens fail the test), the glow-wire test of clause G.2 of annex G carried out at 550 °C.*

Unless otherwise indicated in a part 2, diaphragms, gaskets and sealing rings of glands are not subjected to the tests of this subclause.

21.2.5 *Ball pressure test 1*

The ball pressure test is carried out by means of the apparatus shown in figure 6.

The parts to be tested are stored for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %, before starting the test.

The surface of the part to be tested is placed in the horizontal position and a steel ball of 5 mm diameter is pressed against this surface by a force of 20 N. The thickness of the specimen shall be not less than 2,5 mm; if necessary, two or more layers of the part subjected to the tests shall be used.

The test is made in a heating cabinet at the temperature which is the highest of:

- *(20 ± 2) K [(15 ± 2) K for controls intended for incorporation into appliances within the scope of IEC 60335-1] in excess of the maximum temperature measured during the tests of clause 14, or*
- *(75 ± 2) °C or*
- *as declared.*

The support and the ball shall be at the prescribed test temperature before the test is started.

After 1 h, the ball is removed from the sample which is then cooled down to approximately room temperature by immersion within 10 s in cold water. The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

The test is not made on parts of ceramic material.

21.2.6 Ball pressure test 2

The ball pressure test is carried out as described in 21.2.5 except that the temperature of the heating cabinet shall be (T_b ± 2) °C where:

T_b is equal to the higher of:

- *100 °C when T_{max} is 30 °C and up to, but excluding, 55 °C;*
- *125 °C for controls intended for incorporation into appliances within the scope of IEC 60335-1 (except in-line cord controls) and for other controls when T_{max} is 55 °C and up to, but excluding, 85 °C;*
- *(T_{max} + 40) °C if T_{max} is 85 °C or above;*
- *20 K in excess of the maximum temperature recorded during the heating test of clause 14, if this would produce a higher temperature;*
- *see annex H.*

This test is not made on parts of ceramic material.

21.2.7 Resistance to tracking

All non-metallic parts for which a creepage path is specified between live parts of different polarity, between live parts and earthed metal and between live parts and accessible surfaces (if required by clause 20), shall have a resistance to tracking as declared.

Required values of resistance to tracking are given either in the Part 2s of IEC 60730 or in the relevant equipment standard.

Controls designed for operation at extra-low voltage are not subjected to a tracking test.

Within a control, different parts may have different PTI values appropriate to the micro-environment of the part.

Compliance is checked by the tests of clause G.4 of annex G carried out at one of the following voltages as declared in table 7.2, item 30:

- *100 V;*
- *175 V;*
- *250 V;*
- *400 V;*
- *600 V.*

For the purposes of this clause, the proximity of arcing contacts is not considered to increase the deposition of external conductive material as the endurance tests of clause 17, followed by the electric strength tests of clause 13, are deemed sufficient to determine the effect of pollution arising from within the control.

21.3 Independently mounted controls

21.3.1 Preconditioning

Preconditioning shall be carried out in a heating cabinet prior to the tests of 21.3.2 to 21.3.5, inclusive, as follows:

- *without T rating: 1 × 24 h at (80 ± 2) °C, the circuit of the switching part and the driving mechanism not being connected, with detachable covers removed;*
- *with T rating for temperatures not exceeding 85 °C: 1 × 24 h at (80 ± 2) °C, the switching part of the control and the driving mechanism not being connected and without covers and subsequently 6 × 24 h at (T_{max} ± 2) K with covers, with the circuit of the switching part and driving mechanism being connected;*
- *with T rating for temperatures exceeding 85 °C: 6 × 24 h at (T_{max} ± 2) K with covers, with the circuit of the switching part and driving mechanism being connected.*

21.3.2 Insulating parts retaining live parts shall comply with the requirements of Category B or D.

21.3.3 Accessible non-metallic parts shall comply with the requirements of 21.2.1.

21.3.4 Other non-metallic parts shall comply with the requirements of 21.2.4.

21.3.5 Independently mounted controls shall comply with the requirements of 21.2.7.

21.4 Controls employing a mercury-tube switch intended for connection to a working-voltage circuit as defined in 2.1.3 shall perform acceptably when tested in series with a standard non-renewable cartridge fuse on a d.c. circuit of the voltage specified for test in 17.1.1, except that a.c. with a non-inductive load may be employed if the device is intended for use on a.c. only. The fuse rating and capacity of the test circuit shall be as specified in table 21.4.

The enclosure and any other exposed metal are to be grounded and cotton is to be placed around all openings in the enclosure.

There shall be no ignition of the cotton or insulation on circuit conductors nor emission of flame or molten metal except mercury from the enclosure housing the switch. Wiring attached to the device, except tube leads, shall not be damaged. Successive operations are to be conducted *by alternately closing the mercury-tube switch on the short circuit and closing the short circuit on the mercury tube by means of any suitable switching device.*

Table 21.4 – Mercury switch short-circuit conditions

V	Maximum rating	S.C. current A	Minimum fuse rating [1] [2]		
			0–125	126–250	251–660
0–250	2 000 VA	1 000	20	15	–
0–250	30 A	3 500	30	30	–
0–250	63 A	3 500	70	70	–
251–660	63 A	5 000	–	–	30

[1] Minimum fuse rating shall be at least equal to switch ampere rating or the nearest standard fuse not exceeding four times motor full-load ampere rating and in any case not less than that shown.

[2] For the purpose of this test, ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250. Intermediate size fuses may be used.

Cotton used shall be as specified in annex C.

The switch need not be operative after the tests.

22 Resistance to corrosion

22.1 Resistance to rusting

22.1.1 Ferrous parts, including covers and enclosures, the corrosion of which might impair compliance with this standard, shall be protected against corrosion.

22.1.2 This requirement does not apply to temperature sensing elements or to other component parts whose performance would be adversely affected by protective treatment.

22.1.3 *Compliance is checked by the following test:*

22.1.4 *The parts are subjected to a test of 14 days duration at 93 % to 97 % relative humidity at (40 ± 2) °C.*

22.1.5 *After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surfaces shall show no corrosion which might impair compliance with clauses 8, 13, and 20.*

22.1.6 *Traces of rust on sharp edges and a yellowish film removable by rubbing are ignored.*

Parts protected by enamelling, galvanizing, sherardizing, plating or other recognized equivalent protection are deemed to meet this requirement.

For small helical springs and the like, and for parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film, and the test is then made without removal of the grease.

23 Electromagnetic compatibility (EMC) requirements – emission

See also clause H.23.

23.1 Free standing and independently mounted controls, which cycle during normal operation, shall be so constructed that they do not generate excessive radio interference. Integrated and incorporated controls are not subjected to the tests of this clause, as the result of these tests can be affected by the incorporation of the control in equipment. They may, however, be carried out on such controls if requested by the manufacturer.

Compliance is checked by one of the following methods:

- a) *Testing in accordance with CISPR 14-1, with the following modification and/or CISPR 22, class B. In 4.2.3.4 of CISPR 14-1, the value of 10 ms is replaced by 20 ms.*
- b) *Testing as detailed in 23.1.1 and 23.1.2, resulting in a maximum duration of radio frequency emission of 20 ms. Where such controls have a click rate greater than 5, method a) shall be followed.*
- c) *Examination and/or tests to show that the minimum time between contact operations during normal operation cannot be less than 10 min.*

Compliance with method b) or c) shows compliance with method a).

23.1.1 Test conditions

Three previously untested samples are subjected to the test.

The electrical and thermal conditions are as specified in 17.2 and 17.3, except as follows:

- *for sensing controls, the rate of change of activating quantities is α_1 and β_1.;*
- *for non-sensing controls, the controls are caused to operate at the lowest contact operating speed possible during normal operation;*
- *for controls declared for use with inductive loads, the power factor is 0,6, unless declared otherwise in table 7.2, requirement 7. For controls declared with purely resistive loads, the power factor is 1,0.*

23.1.2 Test procedure

The control is operated for five cycles of contact operation.

The duration of radio interference is measured by an oscilloscope connected to the control so as to measure the voltage drop across the contacts.

For the purpose of this test, radio interference is any observed fluctuation of voltage across the contacts which is superimposed on the supply waveform as a result of contact operation.

24 Components

24.1 Transformers intended to supply power to a safety extra-low voltage circuit (SELV) shall be of the safety isolating type and shall comply with the relevant requirements of IEC 60742.

Capacitors used to provide radio interference suppression shall comply with the requirements of IEC 60384-14.

Fuses shall comply with the requirements of IEC 60127 or IEC 60269, as appropriate.

24.1.1 Controls that incorporate a transformer as the source of supply to an external SELV circuit are subjected to an output test with the primary energized at full rated voltage as indicated in 17.2.2, 17.2.3.1 and 17.2.3.2.

Under any non-capacitive conditions of loading (from no load to the short-circuiting of any or all secondary low-voltage installation wiring terminals) and without disturbing internal connections, the secondary output voltage shall be not greater than that defined in 2.1.5.

The secondary output power at the terminals to the external circuit shall not exceed 100 VA and the secondary output current shall not exceed 8 A after 1 min of operation with overcurrent protection, if provided, bypassed.

24.2 Components other than those detailed in 24.1 are checked when carrying out the tests of this standard.

24.2.1 However, for components which have previously been found to comply with a relevant IEC safety standard, to reduce the testing necessary, assessment is limited to the following:

1) the application of the component within the control is checked to ensure that it is covered by previous testing to the IEC safety standard;
2) testing according to this standard of any conditions not covered by the previous testing to the IEC safety standard.

24.2.2 See also annex J.

25 Normal operation

See annex H.

26 Electromagnetic compatibility (EMC) requirements – immunity

See clause H.26.

In general, the tests of clause H.26 are not applicable to non-electronic controls because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic controls may be included in other clauses of the appropriate part 2.

27 Abnormal operation

27.1 See annex H.

27.2 Burnout test

Controls incorporating electro-magnets shall withstand the effects of blocking of the control mechanism.

Compliance is checked by the tests of 27.2.1 and 27.2.2.

For relays and contactors, compliance with this requirement is established by successful completion of the tests of clause 17.

27.2.1 *The control mechanism is blocked in the position assumed when the control is de-energized. The control is then energized at rated frequency and rated voltage as indicated in 17.2.2, 17.2.3.1 and 17.2.3.2.*

The duration of the test is either 7 h; or until an internal protective device, if any, operates; or until burnout, whichever occurs first.

27.2.2 *After this test the control shall be deemed to comply if:*

- *there has been no emission of flame or molten metal, and there is no evidence of damage to the control which would impair compliance with this standard;*
- *the requirements of 13.2 are still met.*

The control need not be operative following the test.

27.3 Overvoltage and undervoltage test

A control incorporating an electro-magnet shall operate as intended at any voltage within the range of 85 % of the minimum rated voltage and 110 % of the maximum rated voltage, inclusive.

Compliance is checked by subjecting the control to the following tests at the maximum and minimum operating conditions declared, except that only a control having T_{min} less than 0 °C is tested at T_{min}:

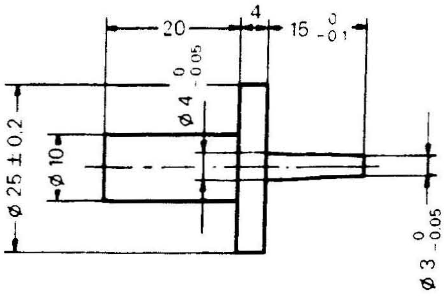
The control is subjected to 1,1 $V_{R\ max}$ until equilibrium temperature is reached and then tested immediately for operation at 1,1 $V_{R\ max}$ and at rated voltage.

The control is also subjected to 0,85 $V_{R\ min}$ until equilibrium temperature is reached and then tested immediately for operation at 0,85 $V_{R\ min}$.

27.4 See annex H.

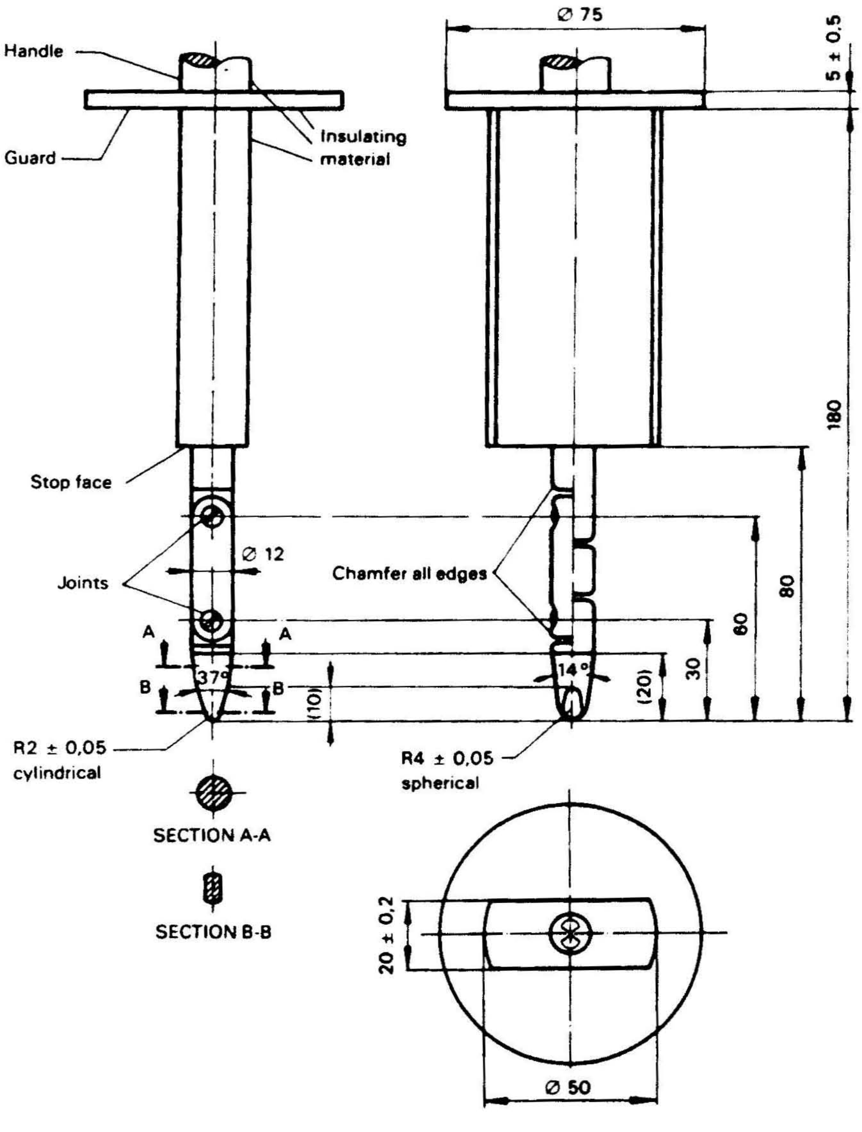
28 Guidance on the use of electronic disconnection

See annex H.



Dimensions in millimetres

Figure 1 – Test pin



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

on angles ${}^{0}_{-10}$ °

on linear dimensions:

up to 25 mm: ${}^{0}_{-0,05}$

over 25 mm: ±0,2

Material of finger: e.g. heat-treated steel.

Both joints of this finger may be bent through an angle of 90 ${}^{+10}_{0}$ ° but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a 90° bending angle with a 0° to 10° tolerance.

Figure 2 – Standard test finger

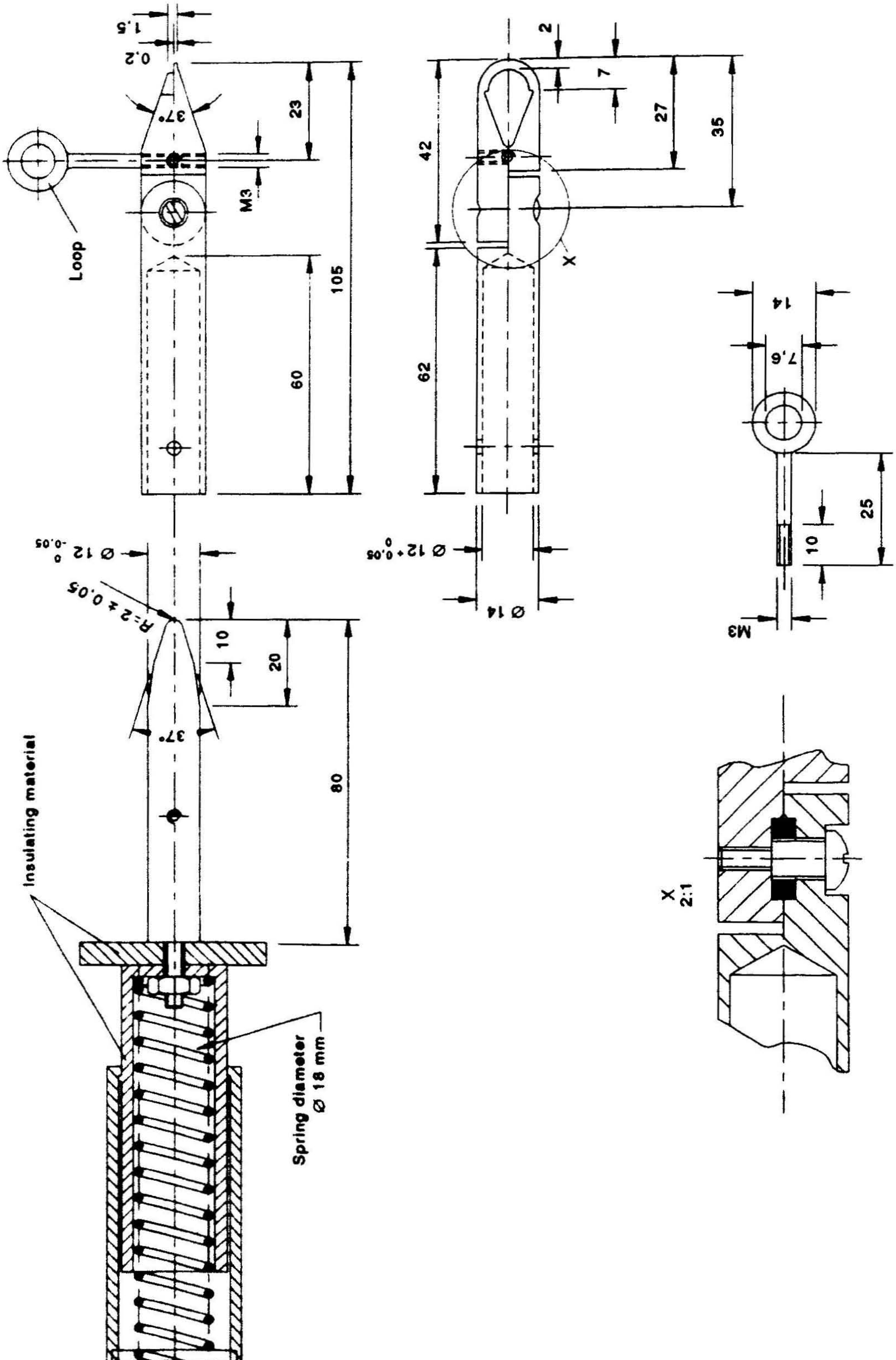


Figure 3 – Test nail

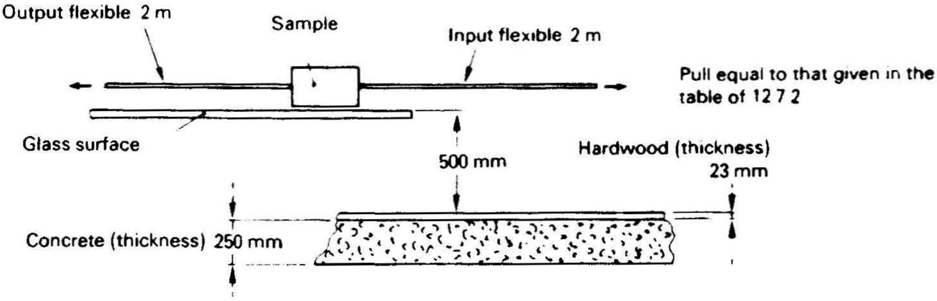
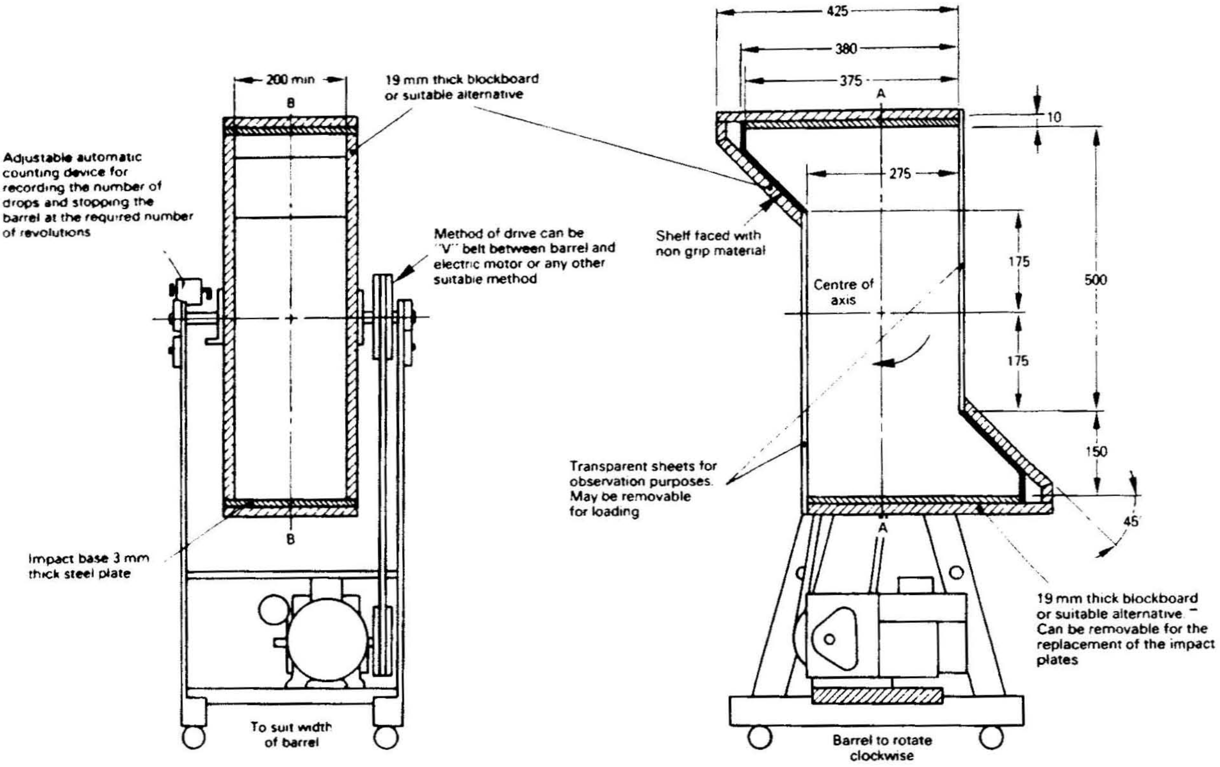

Output flexible 2 m
Sample
Input flexible 2 m
Pull equal to that given in the table of 12 7 2
Glass surface
500 mm
Hardwood (thickness) 23 mm
Concrete (thickness) 250 mm

Figure 4 – Impact test for free-standing controls


200 min
B
19 mm thick blockboard or suitable alternative
Adjustable automatic counting device for recording the number of drops and stopping the barrel at the required number of revolutions
Method of drive can be "V" belt between barrel and electric motor or any other suitable method
Impact base 3 mm thick steel plate
B
To suit width of barrel
425
380
375
A
10
275
Shelf faced with non grip material
Centre of axis
175
500
175
150
Transparent sheets for observation purposes. May be removable for loading
A
45°
19 mm thick blockboard or suitable alternative. Can be removable for the replacement of the impact plates
Barrel to rotate clockwise

Dimensions in millimetres

Figure 5 – Tumbling barrel

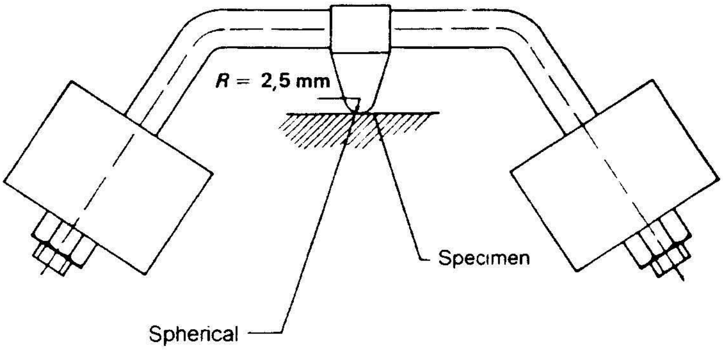
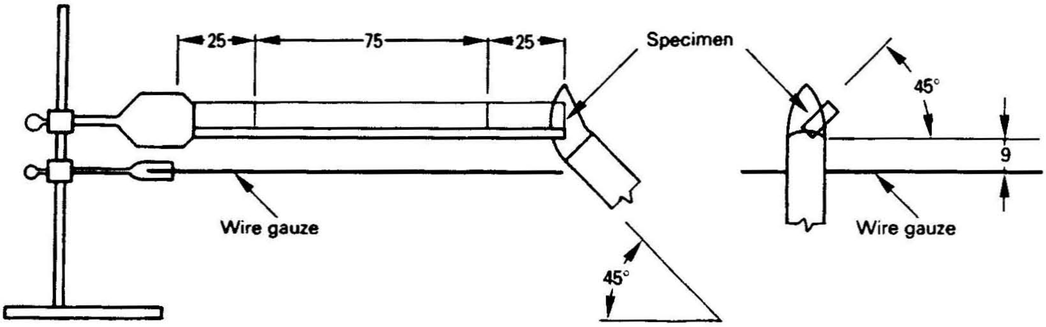
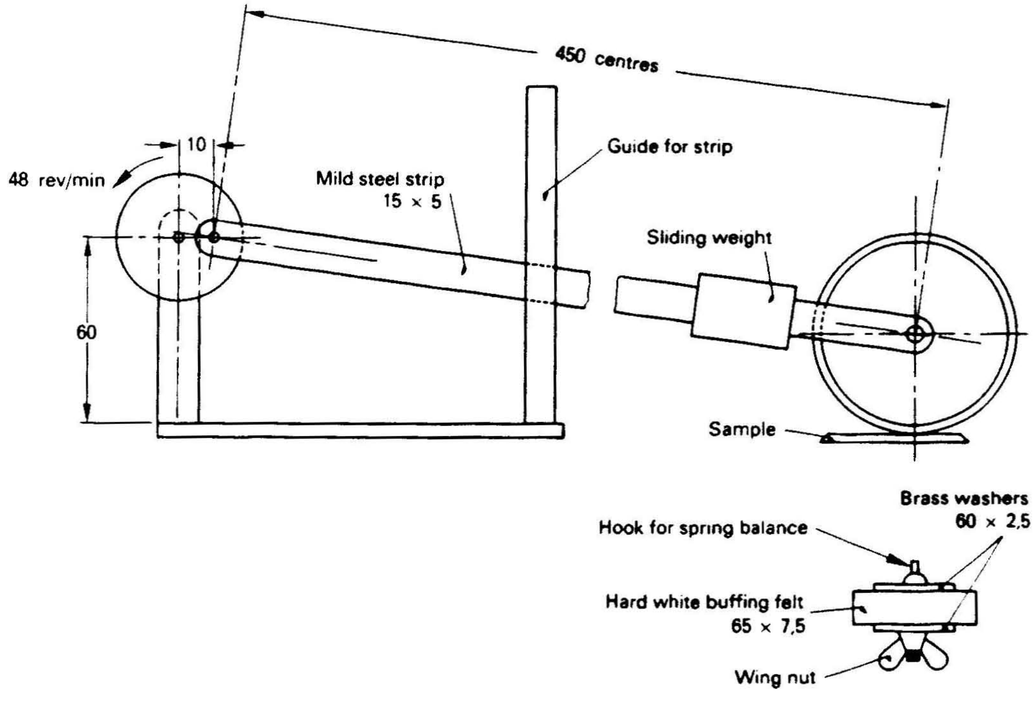


Figure 6 – Ball-pressure apparatus



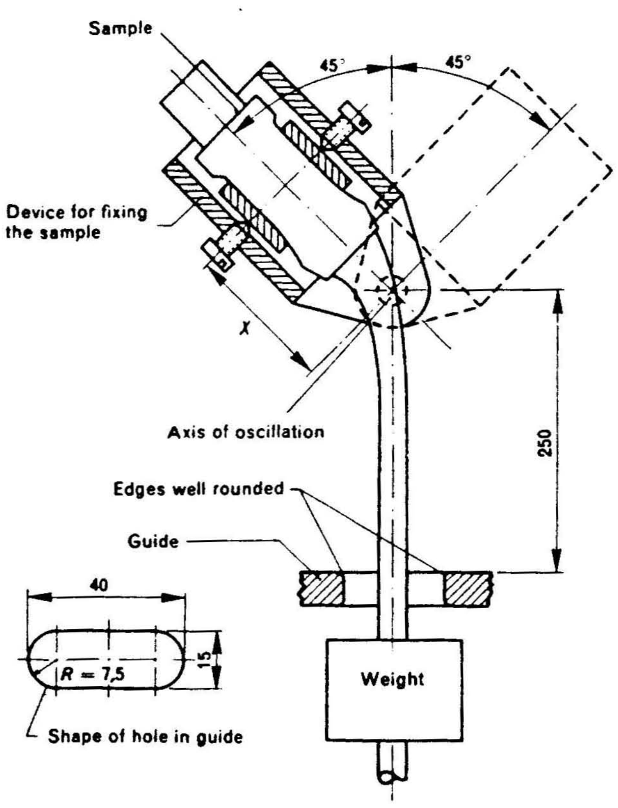
Dimensions in millimetres

Figure 7 – Horizontal burning test



Dimensions in millimetres

Figure 8 – Apparatus for testing durability of markings on rating labels

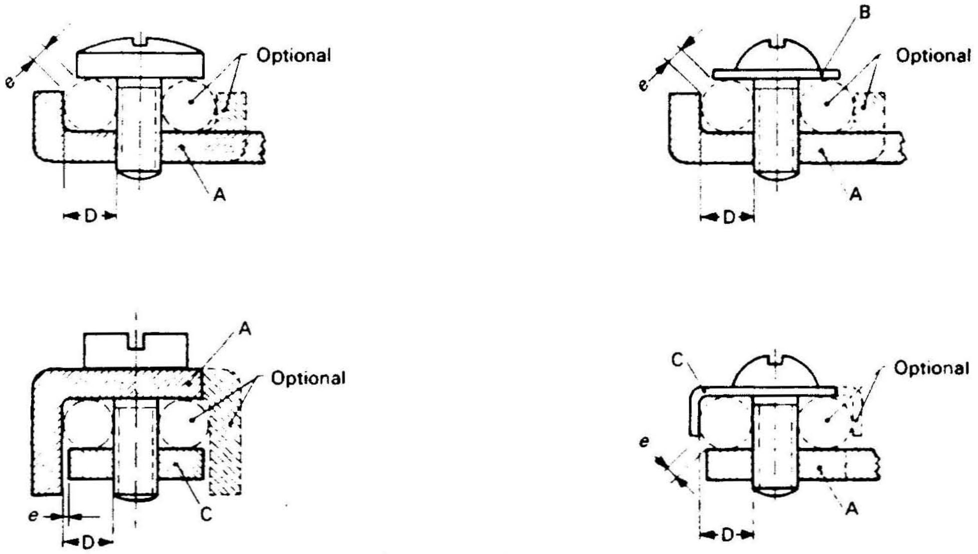


Dimensions in millimetres

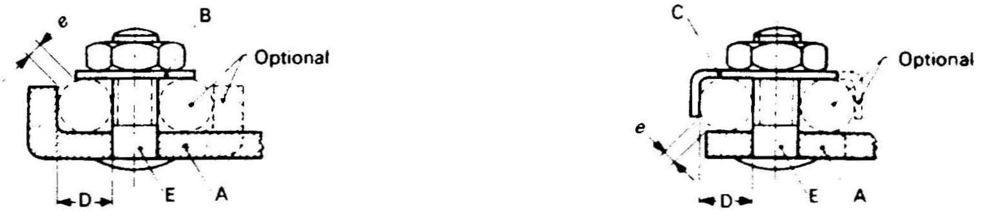
Figure 9 – Apparatus for flexing test

Screws not requiring washer, clamping plate or anti-spread device

Screws requiring washer, clamping plate or anti-spread device



Screw terminals



Stud terminals

A = fixed part

B = washer or clamping plate

C = anti-spread device

D = conductor space

E = stud

Figure 10 – Screw terminals and stud terminals

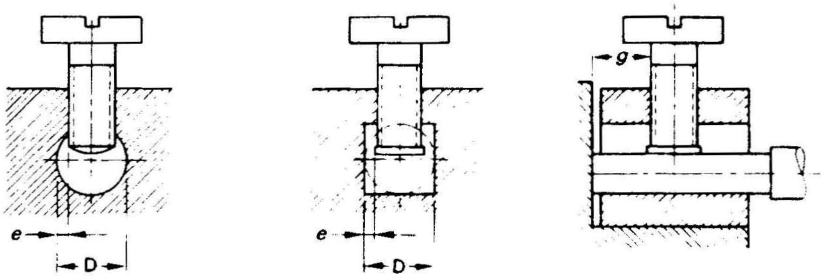
Dimensions in millimetres

Current carried by terminal		**Minimum diameter conductor space**	**Maximum gap between conductor restraining parts**	**Minimum torque** Nm			
For flexible conductor A	**For fixed conductor** A	*D*	*e*	**Slotted screws**		**Other screws**	
				One screw *g*	**Two screws** *g*	**One screw**	**Two screws**
0-6	0-6	1,4	1,0	0,4	–	0,4	–
6-10	0-6	1,7	1,0	0,5	–	0,5	–
10-16	6-10	2,0	1,5	0,8	–	0,8	–
16-25	10-16	2,7	1,5	1,2	0,5	1,2	0,5
25-32	16-25	3,6	1,5	2,0	1,2	2,0	1,2
–	25-32	4,3	2,0	2,0	1,2	2,0	1,2
32-40	32-40	5,5	2,0	2,0	1,2	2,0	1,2
40-63	40-63	7,0	2,0	2,0	2,0	3,0	2,0

The part which retains the conductor in position may be of insulating material, provided that the pressure necessary to clamp the conductor is not transmitted through the insulating material.

The sketches are not intended to govern design except as regards the dimensions shown.

Figure 10 *(concluded)*



Terminal without pressure plate

Terminal with pressure plate

Figure 11 – Pillar terminals

Dimensions in millimetres

Current carried by terminal		Minimum diameter con-ductor space	Maximum gap between conductor restraining parts	Minimum distance between clamping screw and end of conductor when fully inserted		Minimum torque Nm					
For flexible con-ductor	For fixed con-ductor					Screws without heads		Slotted screws		Other screws	
				One screw	Two screws	One screw	Two screws	One screw	Two screws	One screw	Two screws
A	A	*D*	*e*	*g*	*g*						
0-10	0,6	2,5	0,5	1,5	1,5	0,2	0,2	0,4	0,4	0,4	0,4
10-16	6-10	3,0	0,5	1,5	1,5	0,25	0,2	0,5	0,4	0,5	0,4
16-25	10-16	3,6	0,5	1,8	1,5	0,4	0,2	0,8	0,4	0,8	0,4
25-32	16-25	4,0	0,6	1,8	1,5	0,4	0,25	0,8	0,5	0,8	0,5
-	25-32	4,5	1,0	2,0	1,5	0,7	0,25	1,2	0,5	1,2	0,5
32-40	32-40	5,5	1,3	2,5	2,0	0,8	0,7	2,0	1,2	2,0	1,2
40-63	40-63	7,0	1,5	3,0	2,0	1,2	0,7	2,5	1,2	3,0	1,2

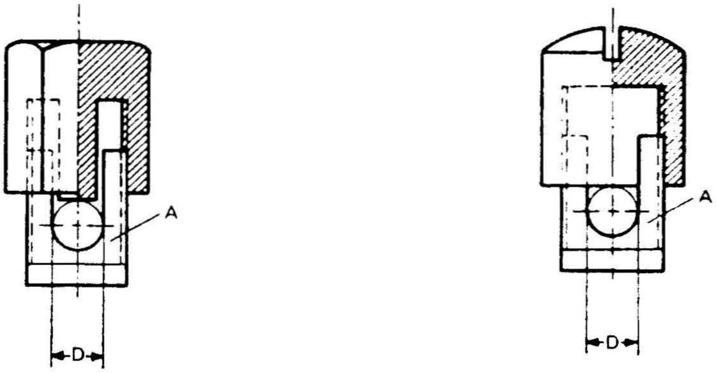
The part of the terminal containing the threaded hole and the part of the terminal against which the conductor is clamped by the screw may be two separate parts; as in the case of terminals provided with a stirrup.

The shape of the conductor space may differ from those shown in the figures, provided a circle with a diameter equal to the minimum value specified for *D* can be inscribed.

The minimum distance between the clamping screw and the end of the conductor when fully inserted applies only to the terminals in which the conductor cannot pass right through.

The sketches are not intended to govern design except as regards the dimensions shown.

Figure 11 *(concluded)*



A = Fixed part

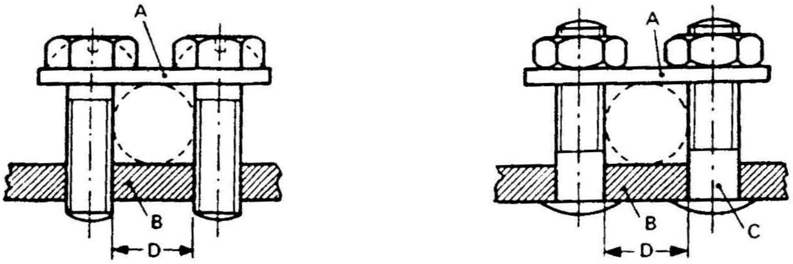
D = Conductor space

The bottom of the conductor space must be slightly rounded, in order to obtain a reliable connection.

Terminal size	Minimum diameter of conductor space 1) mm	Minimum distance between fixed part and end of conductor when fully inserted mm
0	1,4	1,5
1	1,7	1,5
2	2,0	1,5
3	2,7	1,8
4	3,6	1,8
5	4,3	2,0
6	5,0	2,5
7	7,0	3,0
8	8,5	4,0

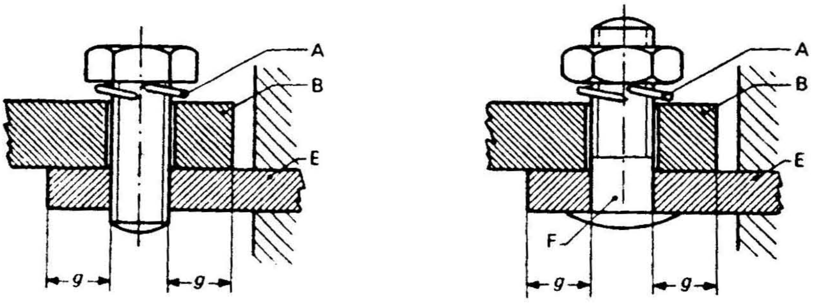
1) The value of the torque to be applied is that specified in table 19.1.

Figure 12 – Mantle terminals



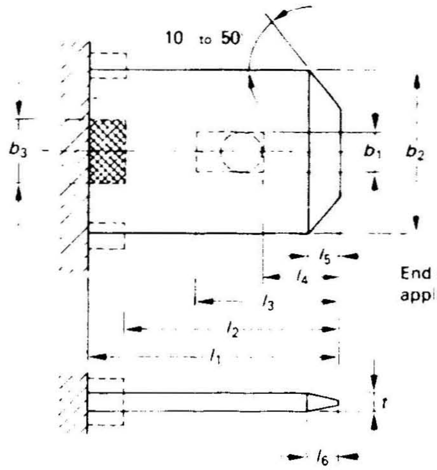
A	Saddle
B	Fixed part
C	Stud
D	Conductor space

Figure 13a – Saddle terminals



A	Locking means
B	Cable lug or bar
E	Fixed part
F	Stud

Figure 13b – Lug terminals



End shaped to facilitate application of receptacle

Dimensions in millimetres

Dimension	Connector size			
	2,8	**4,8**	**6,3**	**9,5**
l_1 (min.) [1]	7,7	6,9	8,6	14,0
l_2 (min).) [1]	7,0	6,2	7,9	12,0
l_3 (max.) [2]	3,0	5,2	6,7	8,2
l_4	1,0 ± 0,2	2,5 ± 0,25	3,2 ± 0,3	4,2 ± 0,3
l_5 (max.)	0,7	1,2	1,3	1,7
l_6 (max.)	0,7	1,2	1,3	1,7
b_1 (hole)	$1{,}2^{+0{,}1}_{0}$	$1{,}4^{+0{,}2}_{0}$	$1{,}6^{+2{,}0}_{0}$ [2]	$2{,}1^{+2{,}0}_{0}$ [3]
b_1 (slot)	$1{,}2^{+0{,}1}_{0}$	$1{,}4^{+0{,}2}_{0}$	$1{,}6^{+0{,}1}_{0}$	$2{,}1^{+0{,}2}_{0}$
b_2	2,8 ± 0,1	4.75 ± 0,2	$6{,}3^{+0{,}15}_{-0{,}1}$	$9.5^{+0{,}15}_{-0{,}1}$
b_3 (min.) [4]	2,0	2,0	2,5	2,5
t [5]	0,5 ± 0,025	0,8 ± 0,03	0.8 ± 0,03	1.2 ± 0.03
p (max.) [6]	0,8	1,2	1,2	1,7
k	–	$0{,}7^{0}_{-0{,}1}$	$1{,}0^{0}_{-0{,}1}$	$1{,}5^{0}_{-0{,}1}$
x	–	1,0 ± 0.2	1,0 ± 0.2	1,4 ± 0,2
t_1 [7]	$^{+0{,}03}_{0}$	$^{+0{,}03}_{0}$	$^{+0{,}03}_{0}$	$^{+0{,}03}_{0}$

[1] In order to provide sufficient clearance for receptacles intended to be provided with a sleeve, it may be necessary to increase this dimension by 0,5 mm to ensure that the means of location operates correctly.

[2] The length of the slot (l_3 l_4) must be at least equal to its width (b_1).

[3] These tolerances are chosen so as to allow the tabs to be used as a part of a terminal with screw clamping.

[4] Over the double hatched area, the thickness shall not exceed the upper limit of the material thickness specified.

[5] A flatness tolerance of ±0,03 mm applies to the thickness of the material measured.

[6] This dimension applies only to the raised side of the tab; on the reverse side, the flatness tolerance extends across the full width of the tab.

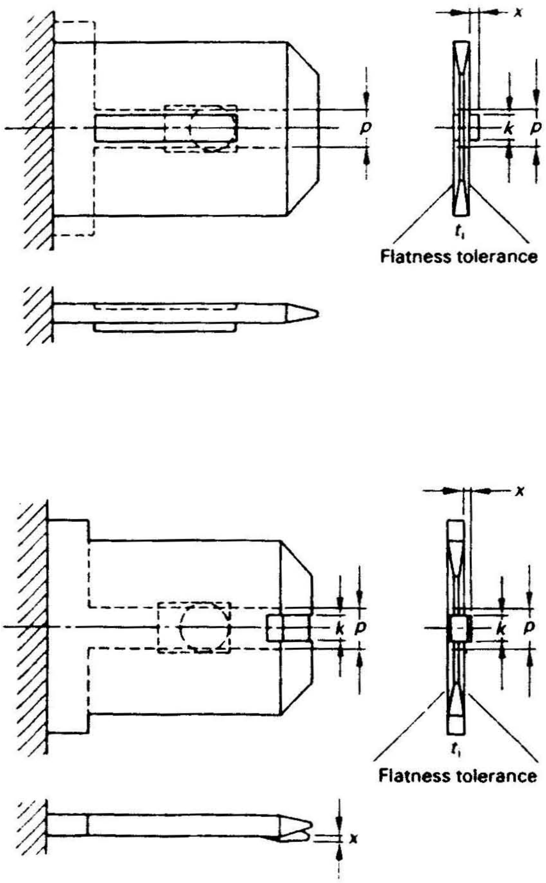
[7] This flatness tolerance applies to the hatched area; the surface of this area shall be free from burrs or protrusions but depressions or holes are permitted if the other dimensional requirements are met.

Tabs may be manufactured from more than one layer of materials provided that the resulting tab complies with this standard sheet.

Details for tabs having corrugations or depressions are under consideration.

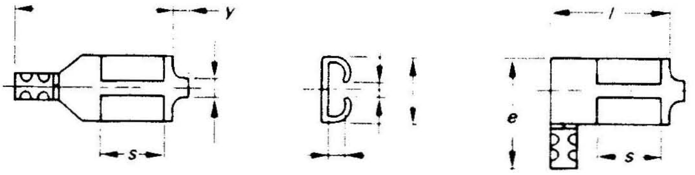
The sketches are not intended to govern design except as regards the dimensions shown.

Figure 14 – Tabs



For dimensions, see figure 14

Figure 15 – Tabs for non-reversible connectors



Centre line of the tab blade

Dimensions in millimetres

Dimension	Connector size			
	2,8	**4,5**	**6,3**	**9,5**
b (max.)	4	6	6	12,5
e (max.)	12	12	15	20
h (max.) [1]	1	2	2,5	3,2
l (max.)	18	18	22	27
s (min.)	4,5	5	6	10
x (min.) [2]	–	0,9	1,2	1,7
y (max.)	0,5	0,5	0,5	1,0
z (max.)	1,5	1,5	2,0	2,0

[1] Maximum offset dimension from the centre line of the tab blade.

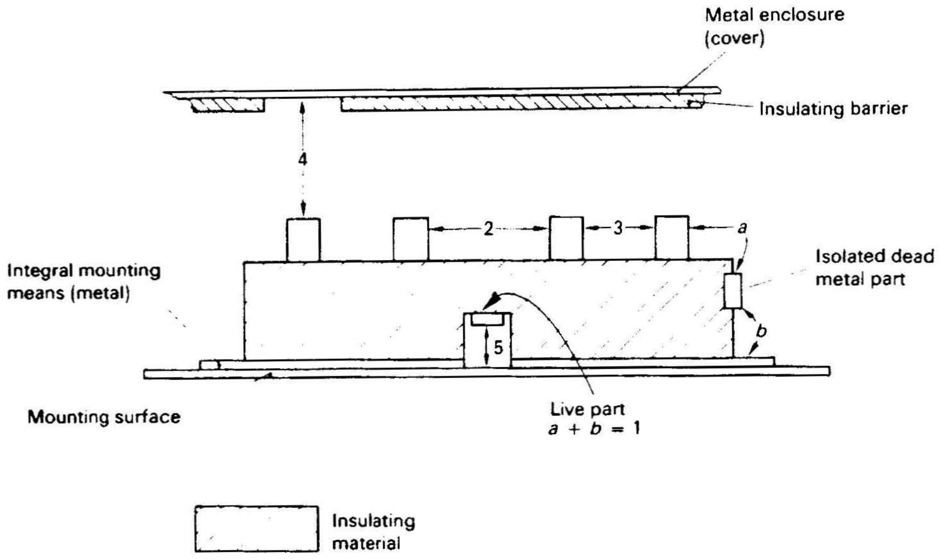
[2] Applies only to receptacles for non-reversible connectors.

The dimensions shown apply to the crimped condition.

Dimensions for receptacles provided with a sleeve and for receptacles with a pre-insulated barrel are under consideration.

The sketches are not intended to govern design except as regards the dimensions shown

Figure 16 – Receptacles



1 = between live parts and other metal parts (including physically exposed electrical isolated metal parts)

2 = between live parts required to be insulated from each other (different polarity), except between contacts.

3 = between live parts separated by the action of the control (same polarity)
a full-disconnection
b these distances do not apply between terminals intended for connection to fixed wiring

4 = between live parts and metal enclosure of enclosed controls (these distances do not apply to the housing, frame or integral mounting means of a control intended for installation within an enclosure of the equipment controlled).

5 = between live parts in recesses of independently mounted controls and the surface to which the control is mounted. This distance may be reduced with the addition of an appropriate seal or barrier.

Figure 17 – Measurement of creepage and clearance

Figures 18 to 24 that are to be found on pages 246 to 250 of the first edition of IEC 60730-1 (1986) have been deleted.

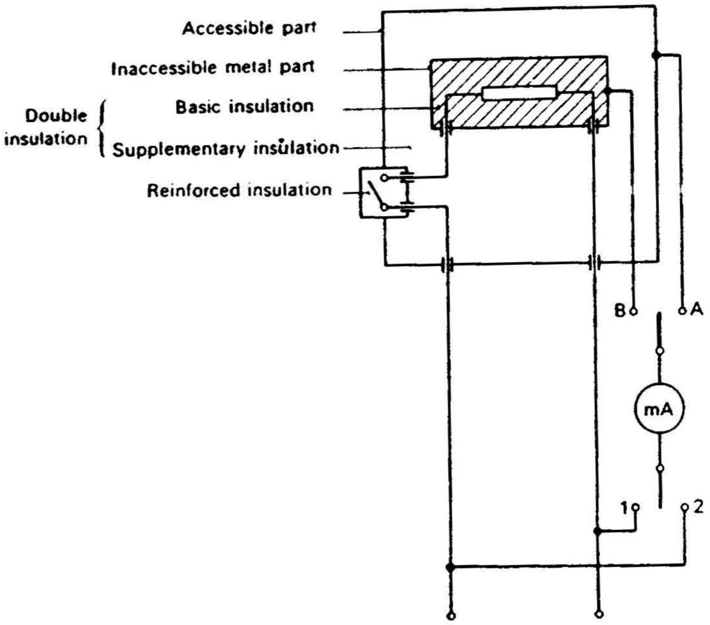


Figure 25 – Diagram for leakage current measurement at operating temperature for single-phase connection of class II controls

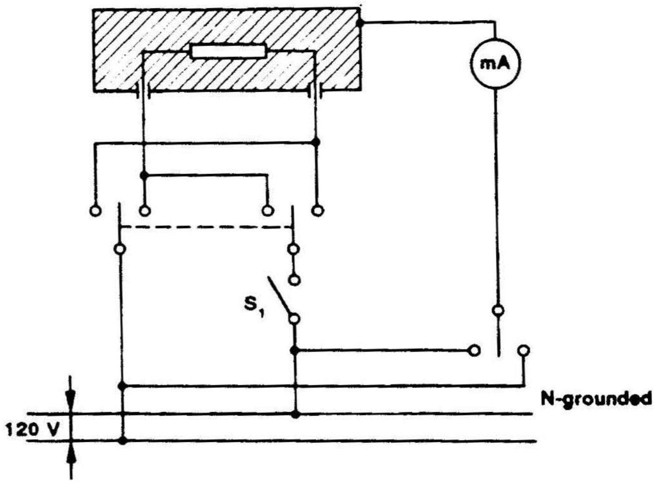


Figure 26 – Diagram for leakage current measurement at operating temperature for single-phase connection of control other than class II

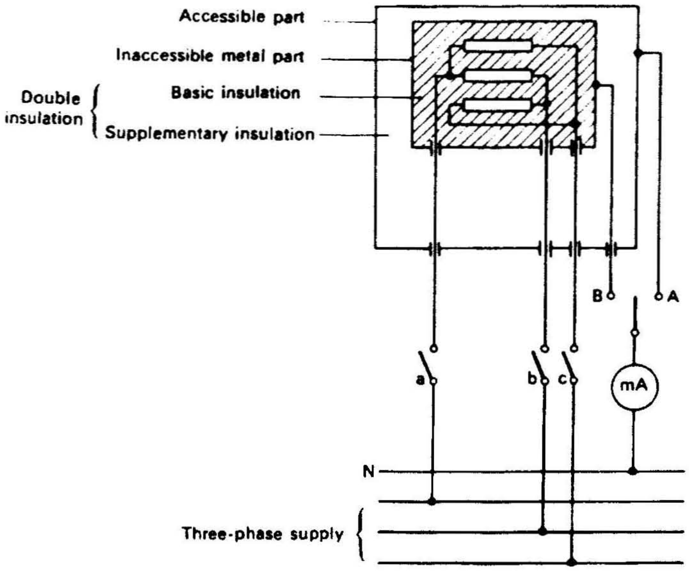


Figure 27 – Diagram for leakage current measurement at operating temperature for three-phase connection of class II controls

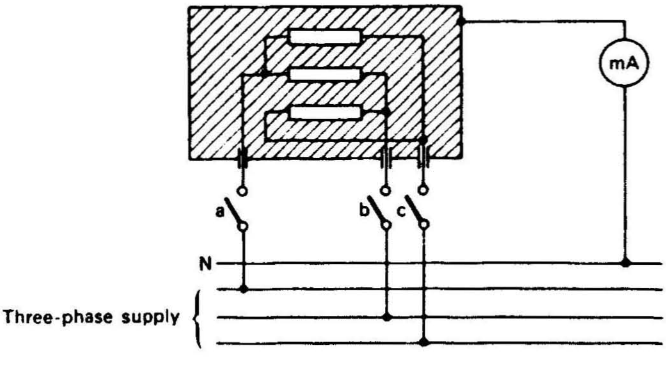


Figure 28 – Diagram for leakage current measurement at operating temperature for three-phase connection of controls other than those of class II

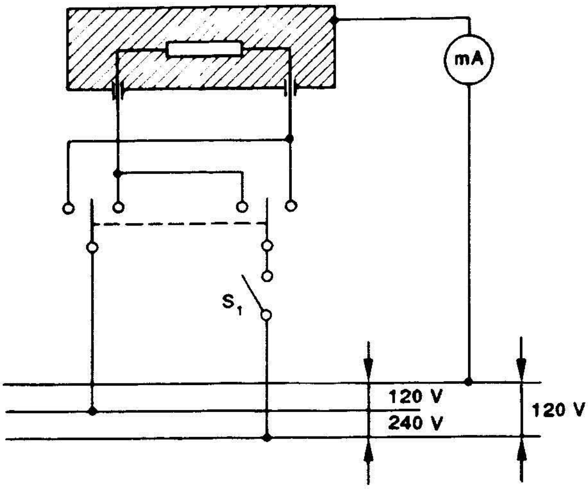


Figure 29 – Diagram for leakage current measurement at operating temperature for single-phase connection of control other than class II

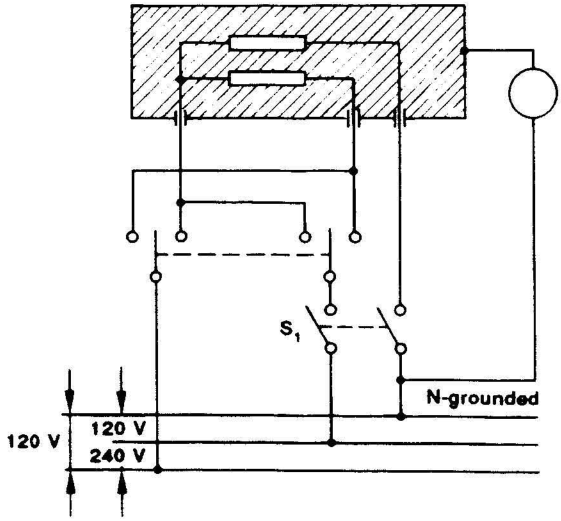


Figure 30 – Diagram for leakage current measurement at operating temperature for two-phase connection of control to three-wire, ground neutral supply other than class II

Annex A
(normative)

Indelibility of markings

A.1 Markings on controls shall be adequately indelible for safety and are therefore classified according to the requirements for indelibility.

A.1.1 Markings which are not mandatory within the requirements of this standard.

A.1.2 Markings which are mandatory within the requirements of this standard but which are not accessible to the final user when the control is mounted or installed in the equipment.

These markings have to be sufficiently resistant to removal to withstand the manual handling in the control manufacturer's factory after final inspection, being packed and transported to the equipment manufacturer's factory, and handled during installation. Additionally, the marking shall remain legible in the presence of any vapour or other contaminant likely to be present.

A.1.3 Markings which are mandatory within the requirements of this standard and which are accessible to the final user of the equipment after the control is mounted or installed as for normal use.

These markings, in addition to being resistant to the handling, etc., described in A.1.2, have also to withstand the rubbing and handling expected during the use of the equipment. Markings on knobs, etc., shall survive the continual handling and rubbing as a result of manual actuation. Other markings should be resistant to cleaning, polishing and the like.

A.1.4 *Compliance with the requirements for indelibility of markings classified according to A.1.2 and A.1.3 of this annex A is checked by the tests of A.2 or A.3 of annex A using the apparatus shown in figure 8.*

The principal part consists of a disc of hard white buffing felt, 65 mm in diameter and 7,5 mm thick. This is locked against rotation and is arranged to move across the surface to be tested with a stroke of 20 mm and to exert a measurable force on this surface. The standard test shall be 12 strokes (i.e., rotations of the eccentric) and shall take approximately 15 s.

During the tests the appropriate part of the buffing disc is covered with one layer of white absorbent lint with the nap surface external.

The solvents used are:

- *neutral liquid detergent blended from alkyl benzene sulphonate and non-ionic detergents;*
- *petroleum spirit (aliphatic solvent hexane with a content of aromatics of maximum 0,1 volume %, a Kauributanol value of 29, initial boiling point of approximately 65 °C and dry point approximately 69 °C, and specific gravity of approximately 0,68 g/cm^3); and*
- *water.*

A.2 *Compliance with the requirements for indelibility of markings classified according to A.1.2 is checked by the following tests:*

A.2.1 *The markings under consideration shall withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

A.2.2 *The sample shall then be allowed to dry completely in an ambient room temperature of (25 ± 5) °C.*

A.2.3 *The sample shall then be rubbed in the apparatus of figure 8, using dry lint and a weight of 250 g measured as indicated.*

A.2.4 *The sample shall then be rubbed using water-soaked lint and a weight of 250 g.*

A.2.5 *If the shape or position of marking is such that it cannot be bleached or rubbed with this apparatus (for example by recessing the marked surface) then the tests of A.2.3 and A.2.4 are not applied.*

A.2.6 *At the conclusion of these tests the marking shall still be legible.*

A.3 *Compliance with the requirements for indelibility of markings classified according to A.1.3 is checked by the following tests:*

A.3.1 *The marking under consideration shall be rubbed in the apparatus of figure 8 using a dry lint and a weight of 750 g.*

A.3.2 *The marking shall then be rubbed in the apparatus using a water-soaked lint and a weight of 750 g.*

A.3.3 *The marking under consideration shall then withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

A.3.4 *After being allowed to dry it shall be rubbed in the apparatus using a detergent soaked lint and a weight of 750 g.*

A.3.5 *After surplus detergent has been shaken off it shall be rubbed in the apparatus, using a petroleum spirit soaked lint and a weight of 750 g.*

A.3.6 *For the tests of A.3.1 and A.3.5 the thickness of the buffing disc may be progressively reduced from 7,5 mm in order that the marking may be reached and rubbed. However, the minimum thickness of the buffing disc shall be not less than 2,5 mm. If the thickness of the buffing disc is reduced the weight of 750 g shall be reduced in linear proportion.*

A.3.7 *At the conclusion of these tests the marking shall still be legible.*

Annex B
(normative)

Measurement of creepage distances and clearances in air

When determining and measuring creepage distances and clearances, the following assumptions are made, where D is equal to the clearance in air prescribed for the distance under consideration:

- *a groove may have parallel, converging or diverging side walls;*
- *if a groove has diverging side walls, it is regarded as an air gap if its minimum width exceeds D/12, its depth exceeds D/2 and its width at the bottom of the groove is at least equal to D/3 (see figure B.8) but in no case smaller than the minimum value X as permitted in the tabulation below.*
- *any corner having an angle less than 80 ° is assumed to be bridged by an insulating link having a width equal to D/3 or 1 mm, whichever is less, which is placed in the most unfavourable position (see figure B.3);*
- *if the distance across the top of a groove is a least equal to D/3, or 1 mm, whichever is less, the creepage path follows the contour of the groove unless otherwise specified immediately above (see figure B.2);*
- *for creepage distances and clearances in air between parts moving relatively one to another, these parts are considered to be in their most unfavourable position to each other;*
- *creepage distances determined according to these rules are not less than the corresponding (measured) clearances in air;*
- *any air gap having a width less than D/3 or 1 mm, whichever is less, is ignored in calculating the total clearance in air;*
- *for inserted or set-up barriers, the creepage distances are measured through the joint unless the parts are so cemented or heat-sealed together that ingress of humidity or dirt into the joint is not liable to occur.*

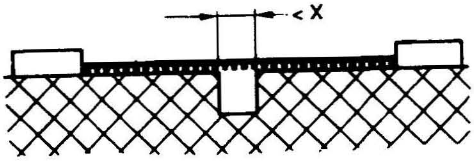
In the examples shown in figures B.1 to B.10, the following identification is used:

.... is a creepage distance;

__________________ is a clearance in air.

Pollution degree	***Width X of grooves: minimum values*** *mm*
1	*0,25*
2	*1,0*
3	*1,5*
4	*2,5*

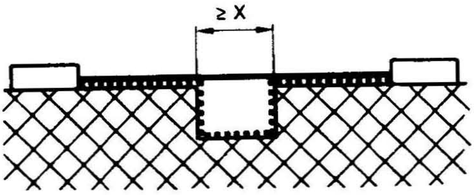
If the associated clearance is less than 3 mm, the minimum groove width may be reduced to one-third of this clearance.



The path under consideration includes a groove of any depth, having a width less than X .

Rule: The clearance path is the "line of sight" path.

Figure B.1

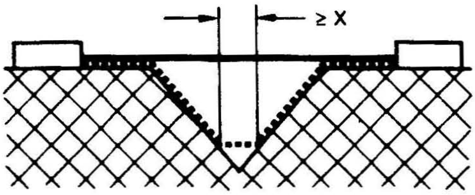


The path under consideration includes a groove of any depth, having a width equal to or more than X.

Rule: The clearance path is the "line of sight" path.

The creepage distance path follows the contour of the groove.

Figure B.2

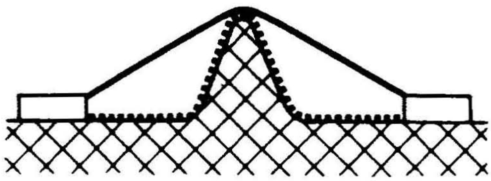


The path under consideration includes a V-shaped groove having an angle less than 80° and a width greater or equal to X.

Rule: The clearance path is the "line of sight" path.

The creepage distance path follows the contour of the groove except that it bridges the groove where its width is equal to X.

Figure B.3

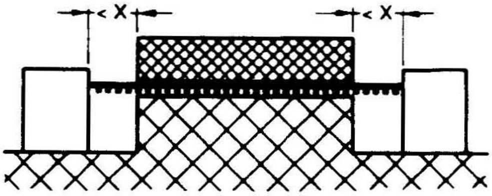


The path under consideration includes a rib.

Rule: The clearance path is the shortest air path over the top of the rib.

The creepage distance path follows the contour of the rib.

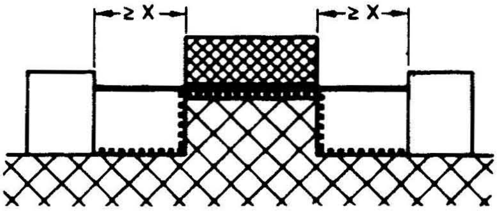
Figure B.4



The path under consideration includes an uncemented joint and grooves having a width less than X on either side.

Rule: Creepage distance path and the clearance path is the "line of sight" path as shown.

Figure B.5

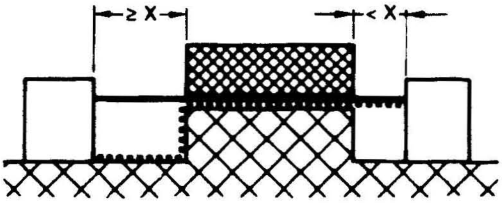


The path under consideration includes an uncemented joint and grooves having a width equal to or more than X.

Rule: The clearance path is the "line of sight" path as shown.

The creepage distance path follows the contour of the grooves.

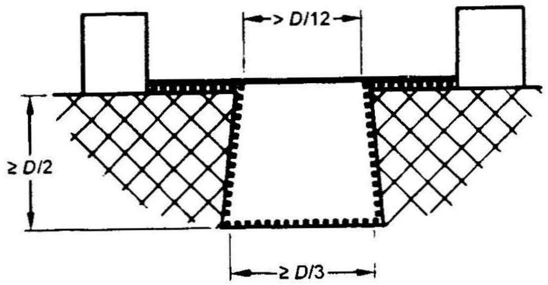
Figure B.6



The path under consideration includes an uncemented joint, a groove on one side having a width less than X, and a groove on the other having a width equal to or more than X.

Rule: The clearance path and the creepage distance path are as shown.

Figure B.7



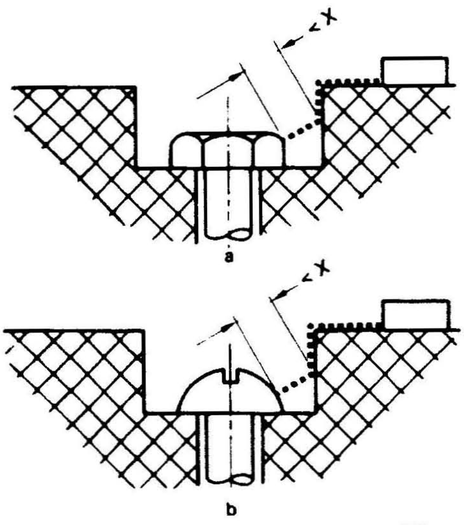
The path under consideration includes a groove having diverging side walls, a depth equal to or greater than D/2 and a width exceeding D/12 at the narrowest part and equal to or greater than D/3 at the bottom.

Rule: The clearance path is equal to the "line of sight" path.

The creepage distance path follows the contour of the groove.

The rule for figure B.3 applies as well to the internal corners if they are less than 80°.

Figure B.8



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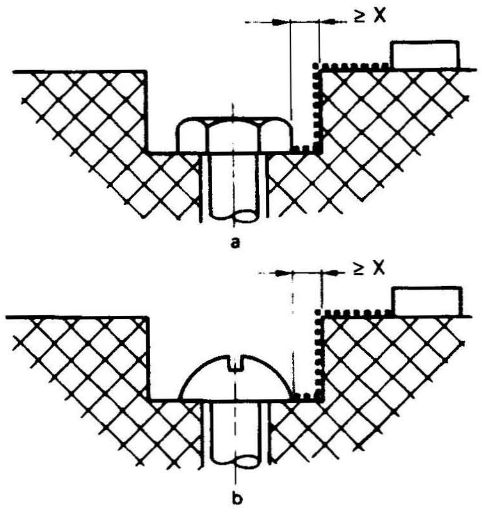


Gap between head of screw and wall of recess too narrow to be taken into account for the creepage distance path.

Gap between head of screw and wall of recess wide enough to be taken into account for the creepage distance path.

Figure B.9

Figure B.10

Annex C
(normative)

Cotton used for mercury switch test

C.1 Classification

Non-sterile

C.2 General requirements

Absorbent cotton shall be made from corded fibres, bleached white, free from adhering impurities and fatty material.

C.3 Fibre length

Not less than 60 % of the fibres by mass shall be at least 12 mm in length; not more than 10 % by mass may be 6 mm or less in length.

C.4 Absorbency

A specimen of cotton shall be completely submerged in water within 10 s. The specimen shall retain not less than 24 times its mass of water.

C.5 Acidity and alkalinity

A water extract of the cotton shall be neutral.

C.6 Residue on ignition

There shall be not more than 0,2 % of residue.

C.7 Water soluble material

There shall be not more than 0,25 % of residue.

C.8 Fatty material

There shall be no trace of blue, green or brownish colour in the ether solution and the amount of residue shall not exceed 0,7 %.

C.9 Dyes

There shall be no evidence of a blue or green tint. A slight yellow is acceptable.

C.10 Other foreign matter

The pinches of cotton taken for determination of fibre length shall not contain oil stains or metallic particles.

Annex D
(informative)

Heat, fire and tracking
(applicable in the USA)

D.1 Insulating materials used for direct and indirect support of live parts

D.1.1 Insulating materials shall comply with any of the flammability classifications according to IEC 60707 and the corresponding electrical, mechanical and thermal requirements given in table D for their intended purpose of either direct or indirect support of live parts.

The tabulated values are used to determine the acceptability of a material as direct and/or indirect support of live parts.

Some materials may not have acceptable levels for the properties listed in table D for direct and/or indirect support of live parts. In such cases, the application shall be considered to determine if the levels specified are necessary or if a reduced value can be accepted without adversely affecting the safety of the end product. For this, D.1.4 to D.1.12 inclusive are intended to be used as a guide in determining acceptability of a material as direct and/or indirect support of live parts.

A polymeric material is acceptable if the same material has been previously accepted for the same type of control, for the same function and conditions, and for the same application, i.e., operating temperature, electrical rating and indoor or outdoor use, etc. However, in practice, it is unlikely that two different designs of controls will have exactly the same circumstances governing temperature, thickness, stress, duty cycle, service life, etc. Thus, the results of an investigation of a particular material in one product is not usually applicable when that same material is used in another product. Because of this, it is generally necessary to make an in-product evaluation of the material in the control.

Suitability of materials with indices other than those recommended in table D may be verified by the indicated tests on the device in its end-product application.

If it is evident from the design and application of the control that a particular test is not applicable, this test is not made.

D.1.1.1 Tests for high voltage arc-tracking resistance and high-voltage arc resistance to ignition need not be conducted if a 12,7 mm clearance is provided between live parts.

D.1.1.2 Non-rigid foamed materials are not acceptable for direct or indirect support of live parts.

Non-rigid foamed materials are those having a tensile or flexural modulus less than 0,69 GPa and a density less than 0,5 g/cm^3.

D.1.2 *Tests for verification of compliance with D.1.1 are made on samples of the same insulating material as used in the device part(s) according to the test standards in table D.*

D.1.3 Relative temperature index test

The relative temperature index shall be determined in accordance with IEC 60216-1. The degradation of properties used for evaluation of the index shall not exceed 50 % of the initial value. The material shall comply with the flammability classification requirements after the thermal endurance.

The evaluation criteria for the relative temperature index shall be according to and at least as follows:

a) *for thermoplastic materials:*
  - *tensile strength: ISO 527*
  - *tensile impact: ----*
  - *dielectric: IEC 60243*

b) *for thermosetting materials:*
  - *flexural strength: ISO 178*
  - *izod impact: ISO R 180*
  - *dielectric: IEC 60243*

D.1.3.1 *The relative thermal index shall be equal to or greater than the temperature of the polymeric material measured during the test of clause 14. The relative thermal index may be based on historical data or a long-term thermal ageing test.*

D.1.3.2 *Thermal ageing tests are not required for polymeric materials exposed to maximum operating temperature, over a reasonable period of time, observed under normal ambient conditions of 65 °C or below for portable controls and 50 °C for stationary and fixed controls. (See clause D.2 for definition of portable, stationary and fixed.)*

However, tests are required on finished parts for electrical and physical properties of table D before and after stress-relief conditioning according to D.1.9. Flammability conditioning is not required for all materials, and stress-relief conditioning is not required for rigid thermosetting materials. Where long-term exposure to temperature is involved, relative thermal index of the material is required.

Table D – Requirements for suitability of insulating material for direct and indirect support of live parts

Property	Application	Use	Test	Method	Units	Requirements related to flammability classification			
	Direct support	Indirect support				FV-0	FV-1	FV-2	FH-1, 2, 3
Flammability	X	X	Flammability	IEC 60707	---				

Engineering considerations:

Flammability classification is intended to serve as a preliminary indication of insulating material suitability with respect to flammability for a particular application. The requirements may be applied to other non-metallic materials if found to be appropriate.

The flammability classification is determined by its response to a standard test flame applied during a specified and limited period, and is related to either its rate of burning or its ability to extinguish upon removal of the test flame. As referred to in this standard, flammability classification is a test on relatively small fixed specimens.

An enclosure of polymeric material having in any single unbroken section, an exposed surface greater than 0,93 m^2, or a single dimension larger than 1,83 m shall be given additional consideration.

In general, materials which react more favourably when tested in a fixed specimen configuration will also react more favourably in an end-product configuration. However, actual ignition performance in an end-product configuration will be affected by the shape and size of the part, heat transfer effects due to heat sinks and the duration of persistence of the ignition source.

FH-3 category applies for materials which are:

1) ≥ 3 mm thick if burning rate ≤ 38 mm/min.

2) < 3 mm thick if burning rate ≤ 76 mm/min.

Property	Application	Use	Test	Method	Units	Requirements related to flammability classification			
	Direct support	Indirect support				FV-0	FV-1	FV-2	FH-1, 2, 3
Electric strength	X	X	Volume resistivity	IEC 60093	Minimum ohm-cm(dry) (after 90 % humidity)	50×10^6 10×10^6	50×10^6 10×10^6	50×10^6 10×10^6	50×10^6 10×10^6

Engineering considerations:

These are normal performance levels associated with insulating materials. A higher level of performance may be required to satisfy end-product tests.

The volume resistivity of an insulation material must be sufficient to prevent dangerous leakage current under all environmental conditions which may be present in an end-product.

This applies for indirect support, if failure of direct support material may cause a possible electric shock.

Table D *(continued)*

Property	Application	Use	Test	Method	Units	Requirements related to flammability classification			
	Direct support	**Indirect support**				**FV-0**	**FV-1**	**FV-2**	**F-H-1, 2, 3**
Electric strength	X	X	Dielectric voltage-withstand	IEC 60243	Minimum volts (r.m.s.) (dry)	5 000	5 000	5 000	5 000
					(after 90 % humidity)[a]	5 000	5 000	5 000	5 000
	Engineering considerations: The dielectric strength of the insulating material shall be sufficient to prevent a breakdown when applied at the normal operating voltage between two adjacent conductors of opposite polarity. The value of the dielectric strength should be sufficient to prevent puncture of the material in the thickness and under the most severe environmental conditions in which it is employed. This applies for indirect support, if failure of direct support material may cause a possible electric shock.								
Tracking	X	–	High-voltage arc tracking resistance	D.1.6	Minimum mm/min.	25,4	25,4	25,4	25,4
	See D.1.6 for test details. The criterion for this test is applied for applications which involve available power greater than 15 W.								
	X	–	Comparative tracking index under moist conditions (CTI)	IEC 60112 Method A	Minimum volts	100	100	100	100
						(as required for creepage but not less than 100)			
	Engineering considerations: This test is intended to show the susceptibility to surface tracking of solid electrical insulating materials when exposed under electrical stress, to a contaminant solution. The CTI value shown has been established contingent upon an end-product connection to a 120 V source and its location in an area which is subject only to moderate contamination effects. Higher CTI values would be required where a greater degree of contamination and/or potentials are involved. Higher CTI values or greater spacings may be required.								

[a] 90 % humidity treatment requires exposure of sample for 96 h in a cabinet to (90 ± 5) % relative humidity at (35 ± 2) °C.

Table D *(continued)*

Property	Application	Use	Test	Method	Units	Requirements related to flammability classification			
	Direct support	Indirect support				FV-0	FV-1	FV-2	F-H-1, 2,3
Permanence	X	X	Dimensional change after water exposure	ISO R62	Maximum % change	2	2	2	2
	Engineering considerations: Materials having a maximum change in dimensions not exceeding the value tabulated have generally been found to provide acceptable end-product performance. Lower values may be necessary where close-fit tolerances are encountered. This property would determine that the material would retain its original dimensions as fabricated, when exposed to high moisture atmospheres, resulting in distortion of the product. The importance of permanence is that the material should not be affected by any of these properties to such an extent that it would impair the operation of controls; or increase the spacing between conductors on its surface, or mounted on it, as to cause a short circuit, create a leakage current path, or permit the live parts to be exposed to personnel contact.								
Distortion under load and mould stress relief	X	X	Heat deflection temperature or	ISO 75	Minimum °C	At 50, 1 g/mm^2 10 °C > in-service temperature but not <90 °C			
	X	X	Vicat softening point or	ISO 306	Minimum °C	25 °C > in-service temperature but not <115 °C or			
	X	X	Ball pressure temperature	IEC 60669-1	Minimum °C	40 °C minus the ambient temperature plus the in-service temperature but not <75 °C			
	Any of the tests tabulated are a relative measure of material ability to withstand stresses while under the influence of elevated temperatures. In applications where the distortion temperature is less than the value indicated, the material may be judged on the basis of the results of the 7 h mould stress relief tests referred to in D.1.9. Basically, this test indicates whether high temperatures would affect internal stress relief within the material causing shrinkage, warpage or other distortion resulting in accessibility to current-carrying parts or creating a possible fire or personal injury.								

Table D *(continued)*

<table>
<tr><th rowspan="2">Property</th><th>Application</th><th>Use</th><th rowspan="2">Test</th><th rowspan="2">Method</th><th rowspan="2">Units</th><th colspan="4">Requirements related to flammability classification</th></tr>
<tr><th>Direct support</th><th>Indirect support</th><th>FV-0</th><th>FV-1</th><th>FV-2</th><th>FH-1, 2, 3</th></tr>
<tr><td rowspan="6">Resistance to electrical ignition sources</td><td>X</td><td>X</td><td>High-current arc resistance to ignition</td><td>IEC 60950 amendment 1 annex D.2</td><td>Minimum number of arcs to ignite</td><td>15</td><td>30</td><td>30</td><td>60</td></tr>
<tr><td colspan="9">This test would determine the ability of the material to withstand arcing on a material's surface at low-voltage/high-current levels, such as would be encountered in the vicinity of contact, or the breaking of internal connections.
High-current resistance to ignition performance profiles are normally conducted at 24 V a.c., and 32,5 A and 50 % power factor. In applications where d.c., a higher potential, current level or lower power factor is involved, testing should be done on the end-product. See D.1.10.
For indirect support, material proximity to arcing parts would be of prime consideration.</td></tr>
<tr><td>X</td><td>–</td><td>Hot wire ignition</td><td>IEC 60950 amendment 1 annex D.3</td><td>Minimum number of seconds to ignition</td><td>10</td><td>15</td><td>30</td><td>30</td></tr>
<tr><td colspan="9">This is a relative test which indicates material resistance to ignition when exposed to abnormally high temperatures resulting from a component failure such as a conductor carrying far in excess of its rated current.
If material characteristics are less than the values specified, see D.1.11.</td></tr>
<tr><td>X</td><td>-</td><td>High-voltage arc resistance to ignition</td><td>D.1.12</td><td>Minimum number of seconds to ignition</td><td>120</td><td>120</td><td>120</td><td>120</td></tr>
<tr><td colspan="9">See D.1.12 for test details.
High-voltage arc resistance to ignition performance profiles are used to measure to ease of igniting a material in the presence of a high voltage, low-current limited arc. This test would be applied where the available power is greater than 15 W. Consideration should also be extended as to whether the flame extinguishes after ignition with the power still applied. Additional consideration should be given to applications where the available potential is greater than 5 000 V.
For indirect support, material proximity to possible high-voltage arcing parts would be of prime consideration.</td></tr>
</table>

Table D *(concluded)*

Property	**Application**	**Use**	**Test**	**Method**	**Units**	**Requirements related to flammability classification**			
	Direct support	**Indirect support**				**FV-0**	**FV-1**	**FV-2**	**FH-1, 2, 3**
Mechanical	X	–	Tensile or flexural Tensile or IZOD impact	ISO R 527 ISO 178 ISO R 180	psi (kg/mm^2) (J/mm notch)	Mechanical strength is judged in the application			
	Engineering considerations: Mechanical strength tests performed under this series may be used to determine mechanical suitability of an alternate or substitute material intended for use in an end-product. This may have the effect of reducing end-product testing. Mechanical strength of the material should be adequate in the application to prevent failure of the part, to prevent live parts which are directly supported by insulating material from moving in the application, or being exposed to contact, or to contact exposed conducting parts of opposite polarity.								
Maximum in-service temperature	X	X	Relative thermal index	IEC 60216	°C	Not lower than the normal operating temperature			
	Engineering considerations: The material, when exposed to temperatures at or below its relative thermal index, should not demonstrate significant degradation of its electrical and mechanical properties at that temperature for the intended life of the end-product. It should be noted that different relative thermal indices may be assigned based on the thickness and properties evaluated. Mechanical strength tests may be used to determine the mechanical suitability of an alternate or substitute material intended for use in an end-product. This may have the affect of reducing end-product testing. Mechanical strength of the material should be adequate in the application to prevent failure of the part, to prevent live parts which are directly supported by insulating material from moving in the application, or being exposed to contact, or to contact exposed conducting parts of opposite polarity.								

D.1.4 Volume resistivity

If the volume resistivity value of the material is less than the value listed in table D, the material could be considered acceptable providing that the control complies with the leakage current requirements in the applicable end-product standard.

D.1.5 Dielectric voltage withstand

If the dielectric voltage withstand value of the material is less than the value listed in table D, the material could be considered acceptable if a thicker section were used to provide the equivalent dielectric withstand but not less than 5 000 V.

D.1.6 High-voltage arc tracking resistance

D.1.6.1 Apparatus

The basic components of the test apparatus are the same as in D.1.12, high voltage arc resistance to ignition, except one of the electrodes is fixed and the other is to be movable in a horizontal direction.

D.1.6.2 *Test specimens are to be the same as described and conditioned prior to arc testing in accordance with D.1.12.2 and D.1.12.3.*

D.1.6.3 Test procedure

Each of the three samples is to be clamped in position under the electrodes. The electrodes are to be placed on the surface of the test sample and spaced 4,0 mm tip to tip and the circuit energized. As soon as the arc track appears on the surface of the sample the movable electrode is to be drawn away as quickly as possible while still maintaining the arc tracking. If the arc extinguishes, the spacing between the electrodes is to be shortened until the arc is re-established and the electrodes are again withdrawn. This process is repeated for 2 min. The length of the conducting path or tracking is measured and the tracking rate determined by dividing by 120 s. If the material tracks readily, the test is to be stopped when the tracking has reached a length of 50,8 mm.

The material is considered to comply with requirements if the tracking rate does not exceed 25,4 mm/min.

D.1.6.4 *If material tracking rate is less than 25,4 mm/min, in applications with an available power greater than 15 W but under 600 V, end-product tests are to be performed on the material, using a hand-held probe, with respect to carbonizing by arcing around an uninsulated conductor using energy available at the material in the control, and using the test criteria described in D.1.10.2, high current arc resistance.*

D.1.6.5 *If material tracking rate is less than 25,4 mm/min in applications higher than 600 V, end-product testing should be conducted to determine that the material can withstand an arcing test without producing a fire. The arc, using the energy available from the parts involved, is to be established between parts of different potential. The arc is to be established by means of a conductive probe. The probe is to be used to break through insulation or to create arc tracking across the surface of insulating materials. The arcing is to be continued for 15 min at each location.*

During the 15 min period, the arcing may be stopped at any time by disconnecting power to the control and the time of flaming measured. If the flame extinguished in less than 30 s, the arcing is to be re-established and continued for the total arcing time of 15 min. In addition, there shall be no permanent carbon conductor path judged by application of a dielectric voltage-withstand potential as required by the equipment standard but not less than 1 000 V, 60 Hz for 1 min.

D.1.6.6 *A construction which would impose a more arc-resistant material between the material being evaluated and earthed parts, accessible conductive parts, and/or live parts of opposite polarity may be considered. If this construction is used, an arcing test is to be performed on the control, using available current and voltage to create an arc between a live part and either earthed parts or a live part of opposite polarity, using a conductive probe.*

D.1.7 Water absorption

Water absorption becomes critical when the application involves outdoor, wet or high-humidity environments. The sample part is to be tested under the worst environmental conditions. This examines the effects on dielectric strength and volume resistivity to determine if unacceptable leakage currents or dielectric breakdown might occur.

D.1.8 Dimensional stability

If the material is prone to dimensional instability after exposure to moisture or water, or after long-term exposure at the use temperature, end-product tests are to be performed in the worst environmental condition to determine if the change in dimension created by the service environment might cause:

- *a reduction of spacings leading to excessive leakage currents;*
- *a dielectric breakdown after such exposure;*
- *warpage or swelling that might impair the acceptable operation of the control.*

D.1.9 Distortion under load and stress relief

In applications where the distortion temperature is less than the values indicated in table D, the material may be judged on the basis of the 7 h stress relief distortion test.

This test is not required for thermosetting materials.

D.1.9.1 *Three samples of the control shall be conditioned in accordance with either item a) or b) below:*

a) The samples are to be placed in an air-circulating oven maintained at a uniform temperature of at least 10 °C higher than the maximum temperature of the material measured during the test of clause 14 but not less than 70 °C.

The samples are to remain in the oven for 7 h. After removal from the oven and return to room temperature, each sample is to be investigated for compliance with D.1.9.2.

b) The samples are to be placed in a test cell. The circulation of air within the cell is to simulate normal room conditions. The air temperature within the cell, as measured at the supporting surface of the control, is to be maintained at 60 °C. The control is to be operated as in the normal temperature test for 7 h. After its removal from the test cell and return to room temperature, each sample is to be investigated for compliance with D.1.9.2.

D.1.9.2 *The material shall be considered as complying with these requirements if the conditioning of the control according to D.1.9.1 does not:*

- *reduce creepage distances and clearances below the minimum acceptable values;*
- *make any bare live parts or internal wiring accessible to contact;*
- *have any undue adverse effect on the insulation;*
- *produce any other condition that might increase the risk of shock, fire, or damage of the control.*

D.1.10 High current arc resistance to ignition

If the characteristic obtained for the sample material when tested according to amendment 1 of IEC 60950 is less than the value specified in table D, the tests are performed on the control under maximum current conditions.

Tests on controls may show that the shape, over-surface distances, thickness, heat sinks, etc., provide more ignition resistance than occurred as a result of testing bar samples using the method described in amendment 1 of IEC 60950.

D.1.10.1 *Current for the arcing test is to be based on the power factor and maximum load-current that the control draws. The voltage used for the test is to be equal to the available voltage at the arcing part. The arc is to be established between the live part and any adjacent part of different potential where breakdown is likely to occur. The arc is to be used to attempt to ignite materials forming parts of the enclosure or to ignite materials located between the parts of different potential. The arc is to be established by means of a copper probe. The probe is to be used to create arc tracking or carbon build-up across the surface of the insulating materials.*

Consideration should be given to material proximity to the arcing parts. The tests are to be conducted above the surface in addition to on the surface when deemed necessary.

D.1.10.2 *After the test, there shall be no ignition as follows:*

- *within 15 arcs for materials classed FV-0;*
- *within 30 arcs for materials classed FV-1, FV-2;*
- *within 60 arcs for materials classed FH-1, FH-2, FH-3.*

In addition, there shall be no permanent carbon conductor path, judged by application of a dielectric voltage-withstand potential as required in the end-product standard, but not less than 1 000 V, 60 Hz for 1 min.

D.1.11 Hot wire ignition

If material characteristic as measured in the tests on bar samples according to clause D.3 of amendment 1 to IEC 60950 are less than the values specified in table D, tests may be conducted on the control using abnormal currents through wires, buses, contacts, or other live parts that are attached to, or routed adjacent to or through, the insulating material. Applicable overcurrent values for the abnormal currents as a function of the circuit overcurrent device rating are given in table D.1.

Table D.1 – Abnormal overload test

Overcurrent protective device rating A	Minimum test time [1]		
	On 110 % current [2] h	On 135 % current min	On 200 % current min
0 – 30	7	60	2
31 – 60	7	60	4
61 – 100	7	120	6
101 – 200	7	120	8
201 – 400	7	120	10
401 – 600	7	120	12

[1] If circuit conditions are such as to open a live conductor, the test circuit current is to be reduced to a point where the circuit remains intact for at least the time indicated but where maximum heat is generated. Opening of a conductor shall not result in a fire or electric shock.

[2] When the circuit stabilizes, the test may be terminated.

D.1.11.1 *If there is no overcurrent protective device or it cannot be relied upon, evaluation is to be based upon the available energy to the control using percentages of the intended branch-circuit overcurrent device, but not less than a 30 A normal-acting branch-circuit device. During or as a result of this test, there shall be no ignition of the material being evaluated.*

D.1.11.2 *If the overcurrent protective device is part of the control, the device shall not be user serviceable unless substitution of a higher rated protective device value is prevented by acceptable keying, other acceptable construction features, or an acceptable permanent marking.*

D.1.12 High voltage arc resistance to ignition

D.1.12.1 Apparatus

The basic components of the test apparatus are to consist of the following:

- *a power transformer rated at 250 VA, 50 Hz-60 Hz, secondary open-circuit 5 200 V a.c. r.m.s.;*
- *a current-limiting resistor bank with a variable nominal resistance of 2,2 MΩ for use in the secondary circuit and capable of limiting the short-circuit current at the electrodes to 2,6 mA;*
- *two test electrodes consisting of No. 303 stainless steel rod having a diameter of 3,2 mm and an overall length of approximately 100 mm. The end is to be machined to a symmetrical conical point having an overall angle of 30°. The radius of curvature at the point is not to exceed 0,1 mm at the start of a given test.*
- *a timer to enable the length of time of test to be determined.*

D.1.12.2 *Test specimens are to be bar samples measuring 127 mm by 12,7 mm by the thickness in question.*

D.1.12.3 *Three samples are to be tested after 40 h of exposure at (23 ± 2) °C and (50 ± 5)% relative humidity. The electrodes are to be mounted in a common plane, parallel to the axis of the test sample, orthogonal to one another, and having an angle of 45° to the horizontal. One of the electrodes is to be fixed, the other located so that there is a spacing across the specimen between the electrodes of 4,0 mm. Each sample is to be clamped in position under the electrodes and the circuit energized.*

The material complies with requirements if the time for ignition to occur after continuous energizing of the test is greater than 120 s.

D.1.12.4 *If material arc resistance to ignition is less than 120 s, end-product tests may be conducted according to D.1.6.4 and D.1.6.5.*

D.1.12.5 *Construction using additional arc-resistant material may be considered according to D.1.6.6.*

D.2 Polymeric materials used for enclosures for portable, stationary and fixed controls

D.2.1 Requirements for polymeric materials used for enclosures are specified in table D.2.

Where the enclosure also serves for the support of live parts, the insulating material shall also comply with the requirements of D.1.1 to D.1.12, inclusive.

Polymeric enclosure materials shall have a temperature rating (relative thermal index) according to D.2.2.

For material used as a decorative part or trim of an enclosure, no material tests are required other than flammability as specified in D.2.2.3.

A portable control is a cord and attachment-plug connected control that is capable of being carried or moved about.

A stationary control is a cord and attachment-plug connected control that is intended to be fastened in place, or located in a dedicated space.

A fixed control is a control that is permanently connected by fixed wiring.

The polymeric material used in the cover of a wall-mounted room thermostat is not subject to the requirements of this subclause but is subject to appropriate requirements of a special investigation.

D.2.2 Temperature rating (relative thermal index)

The relative thermal index shall be according to D.1.3.1 and D.1.3.2. Thermal ageing tests are not required for polymeric materials of enclosures exposed to maximum operating temperature over a reasonable period of time not exceeding the following:

D.2.2.1

– attended, portable, intermittent-duty household controls	80 °C
– other portable controls	65 °C
– stationary and fixed controls	50 °C

For other than rigid thermosetting materials, tests are required according to table D, for physical properties on finished parts before and after stress-relief conditioning to D.1.9.

For polymeric enclosure materials, tests are required for properties after flammability conditioning consisting of 7 days at 70 °C, or 10 K higher than the maximum operating temperature, whichever is higher.

Table D.2 – Tests for polymeric materials used for enclosures

Item	Stationary fixed	Portable
Temperature	D.2.2	same
Flammability	D.2.3.2	D.2.3.1
Ultraviolet resistance	D.2.6	–
Water and immersion	D.2.7	–
Properties	D.2.7.1	–
Dimensions	D.2.7.2	–
Volume resistivity	D.2.8 a) b)	same
Hot-wire ignition resistance	D.2.9 a) b)	a) c)
Distorsion under load	D.2.10 a) b)	same
Heat deflection temperature		
Vicat softening temperature		
Ball pressure temperature		
Impact resistance	D.2.11	same
Crush resistance	D.2.12 a) b)	–
Stress-relief distortion	D.2.13 a) b) d)	same
Input after stress-relief distortion	D.2.14 a) b) e)	g)
Dielectric withstand	D.2.15 a) b)	–
Conduit continuity	D.2.16	–
Conduit pullout, torque, bending	D.2.17	–
Knock-outs	D.2.18	–
Abnormal operation	D.2.19	same
High-current arc resistance to ignition	D.2.20 f)	–
Strain relief	D.2.21	same
Severe conditions	D.2.22 a) b) e)	g)

a) This test is required for materials used to enclose uninsulated live parts.

b) This test is required for material used to enclose insulated live parts with insulation thickness less than 0,71 mm.

c) This test is required for all material used to enclose uninsulated live parts and material classed FH-1, 2, 3 used to enclose live parts with insulation thickness less than 0,71 mm.

d) This test is required for materials used to enclose live parts with insulation thickness equal to or greater than 0,71 mm if lack of performance of intended function by the material causes a stress on the junction between a lead and a terminal, and such controls with integral leads fail to meet appropriate strain-relief tests.

e) This test is required for material used to enclose insulated live parts with insulation thickness equal to or greater than 0,71 mm, and the control is used unattended.

f) This test is required for material used to enclose uninsulated live parts or live parts with insulation thickness less than 0,71 mm, and the material is used for the direct or indirect support of live parts.

g) This test is required for material classed FH-1, 2, 3, and used to enclose uninsulated live parts and live parts with insulation thickness less than 0,71 mm.

D.2.3 Flammability class for polymeric materials used as enclosures

D.2.3.1 Polymeric enclosures of portable controls shall be of a material with a flammability class of FV-0, 1, 2 which are listed in table D. In addition, for enclosures used on portable controls for attended, intermittent-duty household use, the material may be FH-1, 2, 3 of table D.

Where the material has not been evaluated for any of the above classes, the material shall be flame-tested as used in the control according to D.2.4.

Decorative parts or trim for portable enclosures are not required to comply with material tests. A flammability test is not required providing the part occupies a volume of 2 cm^3 or less, no dimension exceeds 30 mm, and is so located that it cannot propagate flame from one area to another or bridge between a possible source of ignition and other parts.

D.2.3.2 Polymeric enclosures for stationary and fixed controls shall be of material with a flammability class LF as determined by the test of D.2.5.

Material used to enclose a metal housing which in turn encloses insulated or uninsulated live parts or is used as a decorative part or trim of the enclosure is not required to comply with material tests.

When the enclosure serves as a rain shield or is not protected against corrosion for outdoor use, material tests are required for ultraviolet radiation, water and immersion, and impact to D.2.6, D.2.7 and D.2.11, respectively.

Decorative parts are not required to have a flammability class providing the part has a volume of 4 000 cm^3 or less, no dimension exceeding 60 mm, and is so located that it cannot propagate flame from one area to another or bridge between a possible source of ignition and other parts.

D.2.4 Portable control enclosures flammability – 19 mm flame

D.2.4.1 Test specimens

Three samples of the control are to be conditioned by being placed in a forced-draught circulating-air oven maintained at a uniform temperature not less than 10 °C higher than the maximum temperature of the material measured under normal operating conditions, but not less than 70 °C. The samples are to remain in the oven for 7 days.

D.2.4.2 Apparatus and gas supply

Apparatus and gas supply is to be the same as specified in table D and IEC 60707 for material classed as FV-0, 1, 2.

D.2.4.3 Test procedure

Three sections of the enclosure of the control most likely to be ignited are selected on each sample. These are considered to be sections adjacent to coils, windings, splices, open-type switches or arcing parts. Non-polymeric portions of the enclosure in contact with or fastened to the polymeric portions are not to be removed and, in so far as possible, the internal mechanism *of the control is to be in place. The control is to be supported in its normal operating position in a draught-free location.*

After conditioning according to D.2.4.1 and on cooling to room temperature, two 30 s applications of the 19 mm flame with no blue cone and with 1 min intervals between their application are to be made to each section of the enclosure as previously selected.

The material is considered to be acceptable if the enclosure does not flame for more than 1 min after the two 30 s applications of the test flame. The material is not acceptable if the test sample is completely consumed.

D.2.5 Stationary and fixed control enclosure flammability – 127 mm flame

D.2.5.1 Test specimens

Three samples of either the control or test specimens of a part or section of the enclosure shall be used. Parts or components which may influence performance are to be left in place. Test specimens, if used, are to be a square of 152 mm x 152 mm of the minimum thickness of the enclosure.

D.2.5.2 Apparatus and gas supply is to consist essentially of the following:

- an air-circulating oven;
- a three-sided enclosure 305 mm x 356 mm deep x 610 mm with top and front of the enclosure to be open;
- a Tirrill gas burner with a bore of 9,5 mm and a length of 102 mm above the air inlets;
- a supply of technical grade methane gas with regulator and meter for uniform gas flow. Natural gas having a heat content of approximately 37 MJ/m^3 has been found to provide similar results;
- a wedge to which the base of the burner can be secured for tilting the barrel 20° from the vertical;
- an adjustable jig to permit positioning of the burner in relation to the test sample.

D.2.5.3 Test procedure

Each sample is to be conditioned for 7 days prior to flame testing in the air-circulating oven maintained at a uniform temperature not less than 10 °C higher than the maximum temperature of the material measured under normal operating conditions but not less than 70 °C. The oven conditioning may be omitted if it has been determined that the material does not exhibit a reduction in its flame-resistant properties as a result of the long-term thermal ageing on specimens of the same or less wall thickness of the enclosure.

The test samples are to be secured with their vertical axis in the center of the three-sided enclosure and with both axes parallel to the back of the enclosure. The room or hood in which the enclosure is located is to be adequately ventilated but draughts are to be prevented from affecting the test flame. The test flame is to be adjusted so that while the burner is vertical, the overall height of the flame is 127 mm and the height of the inner blue cone is 38 mm.

The test flame is to be applied so that the inner blue cone just touches the center of the longitudinal axis of the specimen at an angle of 20° from the vertical.

The flame is applied for 5 s and shut off for 5 s. This procedure is repeated until the samples have been subjected to a total of five applications of the test flame to the same location.

The material is considered to be acceptable if:

- *the material does not continue to burn for more than 1 min after the fifth application of the test flame;*
- *flaming particles do not drip from samples at any time during the test, and*
- *the material is not destroyed in the area of the test flame to such an extent that the integrity of the enclosure is affected.*

If one of the three test samples does not comply, the test is to be repeated on a new sample. If the new sample complies, the material is acceptable (see note).

Compliance with the test of D.2.5.3 determines the LF flammability class.

D.2.6 Exposure to ultraviolet light (outdoor installations)

A polymeric material used for the enclosure of controls that may be exposed to the weather shall be suitably resistant to degradation when exposed to ultraviolet light. As a result of the ultraviolet light conditioning, the flammability classification of the material shall not be reduced, and the physical property values shall be at least 70 % of the values determined before the ultraviolet conditioning.

D.2.6.1 *Two sets of three samples each of unconditioned material shall be subjected to the following tests and the results recorded:*

- *flammability of insulating materials, IEC 60707 and D.2.3.2 for material classified as LF (see D.2.5.3);*
- *for thermoplastic materials*
  1) *Tensile strength to ISO R 527*
  2) *Tensile impact (ASTM D.1822, under consideration as ISO/DIS 8256)*
- *for thermosetting materials*
  1) *Flexural strength to ISO 178*
  2) *Izod impact to ISO R 180.*

D.2.6.2 *The samples shall then be conditioned as follows:*

The samples are exposed to ultraviolet light from two enclosed carbon arcs formed between vertical electrodes 12,7 mm diameter, located at the center of a revolvable vertical metal cylinder 787 mm diameter and 451 mm high. The arcs operate with approximately 15 A to 17 A a.c. and the potential across the arcs is approximately 120 V to 145 V. The arcs are enclosed by globes that are opaque to wave lengths shorter than 2 750 Å and whose transmission improves to 91 % at 3 700 Å. A clear globe of heat resistant optical glass such as No. 9 200 Pyrex may be used.

The samples are to be mounted vertically on the inside of the cylinder in the ultraviolet light apparatus with the width of the samples facing the arcs and not touching each other. The cylinder is to be rotated about the arcs at one revolution per minute and a system of nozzles is to be provided so that each sample is sprayed, in turn, with water as the cylinder rotates. The temperature within the cylinder while the apparatus is in operation is to be approximately 60 °C.

During each 20 min operating cycle of the apparatus, two sets of specimens are to be exposed to light from the carbon arcs for 17 min and to water spray with light for 3 min. The test is to be continued until one set has been exposed to ultraviolet light for a total of 306 h and ultraviolet light and water for a total of 54 h, and the second set 612 h and 108 h, respectively.

D.2.6.3 *After the test exposure, the specimens are to be removed from the test apparatus, examined for signs of deterioration such as crazing or cracking, and retained under conditions of ambient room temperature and atmospheric pressure for not less than 16 h nor more than 96 h before being subjected to flame and physical tests. For comparative purposes, specimens which have not been exposed to ultraviolet light and water are to be subjected to these flame and physical tests at the same time that the final exposed specimens are tested.*

The material complies with requirements if the samples retain 100 % of the initial flammability and not less than 70 % of the mechanical values determined before ultraviolet conditioning.

D.2.7 Water exposure and immersion

D.2.7.1 Properties (for outdoor installations)

D.2.7.1.1 *For material with flammability classification LF (see D.2.5.3), specimens are to be immersed in distilled water at (82 ± 1) °C for seven days with a complete change of water to be made on each of the first five days. Following immersion, specimens to be subjected to flammability test are to be conditioned in air at (23 ± 2) °C and (50 ± 5) % relative humidity for two weeks. Those specimens to be subjected to physical property tests are to be immersed in distilled water at (23 ± 2) °C for 30 min.*

D.2.7.1.2 *For material with flammability classification FV-0, 1, 2 or FH-1, 2, 3, specimens are to be immersed in distilled water at (70 ± 1) °C for seven days with a complete change in water on each of the first five days. Following immersion, specimens to be subjected to flammability or physical property tests are to be immersed in distilled water at (23 ± 2) °C for 30 min.*

D.2.7.1.3 *The material is considered to be acceptable if water conditioning has not reduced the flammability classification. Also, it shall not have reduced the physical properties listed in D.2.6.1 by more than 50 %.*

D.2.7.2 Dimensions

A material that exhibits any dimensional change greater than 2,0 % after immersion for 168 h in distilled water shall be the subject of an appropriate investigation, which may consist of immersion of the entire enclosure to determine the extent of influence of the dimensional change.

To determine the dimensional change, an arc of 100 mm radius is inscribed on the surface of the enclosure or a representative moulded specimen. The sample is then immersed in distilled water at (23 ± 2) °C. After immersion for $24^{+0,5}_{0}$ *h and 167 h – 169 h, additional 100 mm radius arcs are to be inscribed using the original center point as reference. The difference between the original arc and the arcs inscribed after the 24 h and 168 h periods is to be determined with a measuring microscope and shall be used to determine the dimensional change.*

D.2.8 Volume resistivity

A polymeric material used for the enclosure of controls shall comply with the requirements specified in table D for volume resistivity as follows:

- *not less than 50 MΩ/cm after conditioning for 40 h at (23 ± 2) °C and (50 ± 5) % relative humidity, and*
- *not less than 10 MΩ/cm after exposure for 96 h at (35 ± 2) °C and (90 ± 5) % relative humidity.*

D.2.9 Resistance to hot wire ignition

A polymeric material used for the enclosure of equipment shall comply with either of the following two tests:

- *Each of three samples of the material, 127 mm x 12,7 mm and a thickness not more than the minimum thickness of the enclosure is to be wrapped with five turns of resistance wire spaced 6,3 mm between turns. The wire is to be 0,511 mm (No. 24 AWG) iron-free, 20% chromium and 80% nickel, running 5,28 W/m and 120 m/kg. The wire is to carry such current as to dissipate 650 W.*

  The material is considered acceptable if the sample material requires more than 7 s to ignite for portable controls, and 15 s for stationary and fixed controls.
- *The control including the enclosure shall carry the following current:*

Percent branch circuit device rating (20 A min) %	Time
110	7 h
135	1 h
200 (0 A to 30 A)	2 min
200 (31 A to 60 A)	4 min

The material is considered acceptable if there is no ignition of the enclosure.

D.2.10 Distortion under load

A polymeric material used for an enclosure shall comply with the following:

D.2.10.1 *Heat deflection temperature shall be according to table D.*

D.2.10.2 *Vicat softening point shall be at least 10 °C greater than the operating temperature but not less than 115 °C tested according to ISO 306.*

D.2.10.3 *Ball pressure temperature shall be according to table D.*

D.2.11 Resistance to impact

Enclosures of polymeric material shall withstand the impact described in D.2.11.1 and D.2.11.2 as applicable and shall meet the requirements specified in D.1.9.2.

D.2.11.1 *Portable controls supported by the user during operation shall be subjected to the drop impact test as described in a) and b) below.*

a) Each of three samples of the control is to be dropped through 0,91 m to strike a hardwood surface resting on a non-resilient floor in the position most likely to produce adverse results.

b) Each of three samples of the control is to be dropped three times so that in each drop the sample strikes the surface in a position different from those in the other two drops.

D.2.11.2 *Stationary, fixed and portable controls not likely to be dropped, such as counter-supported controls, shall be subjected to the following test as described in a) and b) below:*

a) Each of the three samples of the control shall be subjected to an impact on any surface that is exposed to a blow during normal use or during installation. For an enclosure having no surface area exceeding 258 cm², the impact is to be 6,8 J produced by dropping a steel sphere 51 mm in diameter and weighing 0,535 kg from a height of 1,3 m. For an enclosure having any surface area of more than 258 cm², the impact is to be 13,6 J produced by dropping the previously described steel sphere from a height of 2,6 m. The test may be conducted at any ambient room temperature within the range of 10 °C to 40 °C.

b) Each of three samples of the control shall be cooled to 0 °C for indoor applications and to –32 °C for outdoor applications and maintained at that temperature respectively for 3 h. Immediately following removal from the cold chamber, the sample shall be subjected to the impact test described in a) above.

D.2.12 Crush resistance

Three samples of the control shall be mounted on a fixed rigid supporting surface. Crushing force shall be applied to the side opposite the mounting surface by applicators having flat surfaces, each 102 mm × 254 mm. Each applicator is to exert 445 N on the sample. As many applicators are to be used as the sample can accommodate on the surface opposite the mounting surface, the distance between applicators in a horizontal plane (small dimension of applicator) being 254 mm, and in a longitudinal plane (large dimension of applicator) being 152 mm.

After the test, the control shall meet the requirements specified in D.1.9.2 for stress-relief distortion.

D.2.13 Stress-relief distortion

Polymeric materials, except for rigid thermosetting material, used for enclosures of controls shall meet the following requirements:

- *enclosures for portable controls for attended intermittent duty household use classified as FH-1, 2, 3, and enclosing uninsulated live parts, or insulated live parts with insulation thickness less than 0,71 mm, shall comply with D.2.13.2;*
- *enclosures for all other portable controls and for stationary and fixed controls shall comply with D.2.13.1 except, for materials enclosing live parts with insulation thickness equal to or greater than 0,71 mm, this test is required only where failure of the control causes a stress on the junction between a lead and terminal of the equipment, and for such controls with integral leads not meeting the strain-relief test.*

D.2.13.1 *One sample of the control shall conform to the test and requirements of D.1.9.1 and D.1.9.2.*

D.2.13.2 *One sample of the control shall be tested according to D.1.9.1 and D.1.9.2, except the value to be used for temperature of the material shall be that measured during the conditioning of the severe conditions test of D.2.22.*

If the control burns out as a result of the conditioning of D.2.22, the oven temperature for the test shall be 10 °C higher than the maximum enclosure temperature measured during the test of clause 14, or the highest temperature measured under D.2.22 without burning out.

D.2.14 Input after stress-relief distortion test

Polymeric materials used for enclosures of

- *portable controls for attended, intermittent duty household use, material classified as FH-1, 2, 3, and enclosing uninsulated live parts or live parts with insulation thickness less than 0,71 mm and*
- *stationary and fixed controls which may be used as described by the notes of table D.2 shall comply with the test of D.2.14.1.*

D.2.14.1 *After conditioning as described in D.2.13, the control is to be connected to a supply circuit of maximum rated voltage and rated frequency, except that, if the rated voltage is in the range 105 V to 120 V, the potential of the supply circuit is to be 120 V and, if the product range is 210 V to 240 V, the potential is to be 240 V.*

If primary circuit adjustments are provided, they are to be set for the maximum voltage in 105 V to 120 V or 210 V to 240 V range and the potential of the supply circuit is to be 120 V or 240 V, whichever is applicable.

When operated at no-load and rated voltage, the control shall have an input current no more than 150 % of the current measured during the applicable input test on an unconditioned sample.

D.2.15 Dielectric withstand

Polymeric material of an enclosure depended upon as electrical insulation shall have a dielectric withstand of 5 000 V as specified in table D.

D.2.16 Conduit continuity

The continuity of the conduit system shall be metal-to-metal contact. If the integrity of the polymeric enclosure is relied upon to provide for bonding between the parts of the conduit system at any place where conduit may be connected, the bonding shall be subjected to creep tests conducted at various oven-conditioning temperatures and overcurrent tests shall be conducted at 200 % of the rated current of the branch-circuit protection device.

D.2.17 Conduit pull-out, torque, bending

A polymeric enclosure intended for connection to a rigid conduit system shall withstand, without pulling apart, or damage such as cracking and breaking, a pull-out test, torque test and bending test.

The torque test does not apply to an enclosure that is not provided with a preassembled conduit hub and that has instructions stating that the hub is to be connected to the conduit before being connected to the enclosure.

D.2.17.1 Pull-out

The enclosure is to be suspended by a length of rigid conduit installed in one wall of the enclosure and a direct pull of 890 N is to be applied for 5 min to a length of conduit installed in the opposite wall.

D.2.17.2 Torque

The enclosure is to be securely mounted as intended in service. A torque given in table D.3 is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit

Table D.3

Diameter of conduit mm	**Torque** Nm
$d \leq 19$	90,4
$19 < d < 38$	113
$38 \leq d$	181

An enclosure which has only provisions for an incoming but not an outgoing conduit and a conduit diameter 19 mm maximum is only subjected to a tightening torque of 22,6 Nm.

D.2.17.3 Bending

A suitable length of conduit, at least 305 mm long, of the proper size is to be installed:

- *in the center of the largest unreinforced surface, or*
- *in a hub or an opening if provided as part of the enclosure.*

The enclosure is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The weight necessary to produce the desired bending moment when suspended from the end of the conduit is to be determined from the following formula:

$$W = \frac{M - 0{,}5\ CL}{L}$$

where

W is the weight in kg, to be hung at the end of the conduit;

L is the length of the conduit, in metres, from the wall of the enclosure to the point at which the weight is suspended;

C is the weight of the conduit in kg;

M is the bending moment required in kg.m.

The bending moment corresponding to the conduit diameter is given in table D.4. If the enclosure surface may be installed in either a vertical or horizontal plane, the vertical bending moment value shall be used.

Table D.4

Normal mounting plane of enclosure surface	**Conduit diameter** mm	**Bending moment** Nm	
		Metallic	**Non-metallic**
Horizontal	All	33,9	33,9
Vertical	$d \leq 19{,}3$	33,9	33,9
	$d > 19{,}3$	67.8	33,9

The test may be terminated prior to attaining the values specified if the deflection of the conduit exceeds 254 mm for a 3 048 mm length of conduit.

For an enclosure which has only provisions for an incoming but not an outgoing conduit, the bending moment is 16,9 Nm.

D.2.18 Knockouts

If knockouts are incorporated in the design of an enclosure made of polymeric material, they shall remain in place when subject to a force of 89 N applied at right angles by means of a mandrel with a 6,35 mm diameter flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

D.2.19 Abnormal operation

The control is to be operated under the most adverse condition of abnormal operation such as stalled rotor, blocked armature of relay, burnout of transformer or operation with current-carrying parts short-circuited, and the like, with only one abnormal condition applied at a time. During the test, the control is to rest on white tissue paper on a softwood surface and a single layer of cheese cloth is to be draped over the control. The control is to be operated continuously until ultimate results have been determined. In most cases, continuous operation for 7 h may be necessary to obtain ultimate results.

The enclosure will be acceptable if there is no ignition of the enclosure material, exposure of live parts, emission of flame or molten metal, nor glowing or flaming of the combustible material upon which the control is mounted or with which it is draped.

Warping, shrinkage, expansion, or cracking of the enclosure material, provided that there is not ignition of the combustible indicators, is acceptable. Emission of flame or molten metal is permissible through an opening normally provided in the enclosure and not an opening that occurs as a result of this test.

D.2.20 High current arc resistance to ignition

A polymeric material used for an enclosure as support of live parts for stationary and fixed controls shall not ignite when subjected to at least 30 arcs for material classified as FL (see D.2.5.3) and 60 arcs for material classified as FH-1, 2, 3 in accordance with the tests specified in table D.

For material not meeting the above requirement, the material may be evaluated by interrupting the available energy (current, voltage and power factor) of the control 30 times for LF material and 60 times for FH-1, 2, 3 material on the surface of the material without ignition of the enclosure.

For portable controls, polymeric enclosures of class FV-0, 1, 2 or FH-1, 2, 3 shall resist being ignited when subjected to 30 arcs in accordance with the test specified in table D.

The test need not be conducted if live parts are located at least 12,7 mm from the enclosure. Material not meeting these requirements may be evaluated by using the available energy (current, voltage and power factor) of the circuit for the control.

D.2.21 Strain-relief test

A strain-relief test is required only if a strain-relief means is mounted in the enclosure.

After the test samples have cooled to room temperature following the oven conditioning specified in the stress-relief distortion test in D.1.9, the sample shall be subjected to a strain relief test as applicable to the control.

D.2.22 Severe conditions

This subclause applies to enclosures for controls described by the notes of table D.2.

D.2.22.1 *The control is to be operated as described in items a) to c) below until ultimate results have been determined. The maximum temperature of the enclosure material during the conditioning, or prior to burnout, if burnout occurs, shall be recorded. During the test, the control shall rest on white tissue paper on a softwood surface and is to be draped with a single layer of cheesecloth over the entire control.*

a) *Unless the control is provided with a momentary-contact line switch (one which requires constant pressure to hold it in the ON position) and no means for locking the switch in the ON position, a sample control shall be operated at no-load and rated voltage (see D.2.14.1) for 7 h.*

b) A sample control shall be operated at 106 % of rated voltage (see D.2.14.1) under the same conditions of use as for the test of clause 14.

c) A sample control shall be operated at 94 % of rated voltage (see D.2.14.1) under the same conditions of use as for the test of clause 14.

A manufacturer may elect to use the same sample for each of the conditioning methods a), b) and c) above.

For each of the conditioning methods a), b) and c), any automatic reset or user-serviceable overload protective device provided with the control is to be bypassed unless the protective device has been shown by separate investigation to reliably clear the circuit at the current and power factor levels involved.

Each test is to continue until

- *stable conditions are obtained and burnout does not occur, or*
- *the control has a no-load current input higher than 150 % of the no-load current input on an unconditioned control and burnout does not occur, or*
- *burnout occurs.*

D.2.22.2 *The results are acceptable if*

- *burnout of the control does occur during the conditioning and the no-load current input is not greater than 150 % of the no-load current input on an unconditioned sample, or*
- *burnout occurs, but does not result in flaming of the enclosure which persists for more than 1 min, or ignition of the combustible material indicator.*

D.3 Reference documents

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60243, *Electrical strength of insulating materials – Methods of test*

IEC 60669-1:1998, *Switches for household and similar fixed-electrical installations – Part 1: General requirements*

IEC 60950:1991, *Safety of information technology equipment*

ISO 62:1980, *Plastics – Determination of water absorption*

ISO 75, *Plastics – Determination of temperature of deflection under load*

ISO 178:1993, *Plastics – Determination of flexural properties*

ISO 180:1993, *Plastics – Determination of Izod impact strength*

ISO 527:1993, *Plastics – Determination of tensile properties*

ISO 8256:1990, *Plastics – Determination of tensile-impact strength*

Annex E
(normative)

Circuit for measuring leakage current

A suitable circuit for measuring leakage current in accordance with H.8.1.10 is shown in figure E.1.

The circuit comprises a rectifier arrangement with germanium diodes D and a moving-coil meter M, resistors and a capacitor C for adjusting the characteristics of the circuit, and a "make-before-break" switch S for adjusting the current range of the instrument.

The most sensitive range of the complete instrument must not exceed 1,0 mA, higher ranges being obtained by shunting the coil of the meter by non-inductive resistors R_s and simultaneously adjusting the series resistors RV so as to maintain the total resistance $R_1 + RV + R_m$ of the circuit at the value specified.

The basic calibration points, at a sinusoidal frequency of 50 Hz or 60 Hz, are 0,25 mA, 0,5 mA and 0,75 mA.

The circuit may be protected against overcurrents, but the method chosen shall not affect the characteristics of the circuit.

The resistance R_m is calculated from the voltage drop measured across the rectifier arrangement at 0,5 mA, the resistance RV being then adjusted so as to give the total resistance of the circuit for each range.

Germanium diodes are used, because these have a lower voltage drop than other types of diodes, thus resulting in a more linear scale; preference is given to gold-bonded types. The rating of the diodes shall be chosen so as to suit the desired maximum range of the complete instrument; however, this range shall not exceed 25 mA, because diodes suitable for higher currents have a high voltage drop.

It is recommended that the switch be so arranged that it automatically returns to the position giving the highest current range, in order to prevent inadvertent damage to the instrument.

The capacitor may be made up by selecting capacitors having preferred values and using a series/parallel arrangement.

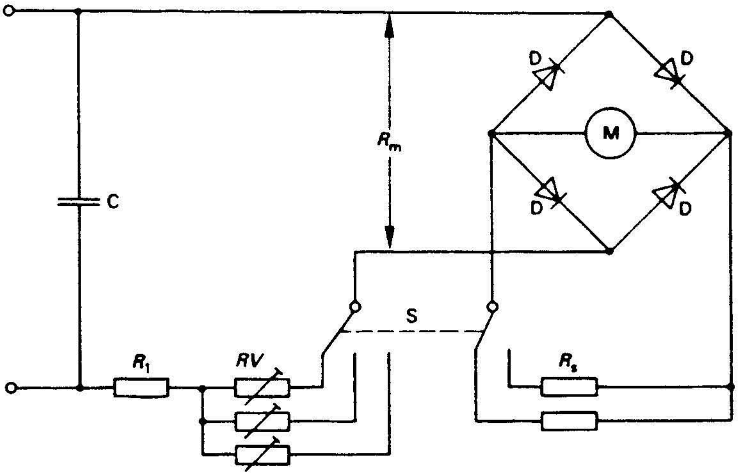


Figure E.1 – Circuit for measuring leakage currents

Annex F
(informative)

Heat and fire resistance categories

F.1 The following descriptions of heat and fire resistance categories are based on IEC 60335-1 and are given for information only. Requirements for heat and fire resistance are contained in the appropriate equipment standard(s).

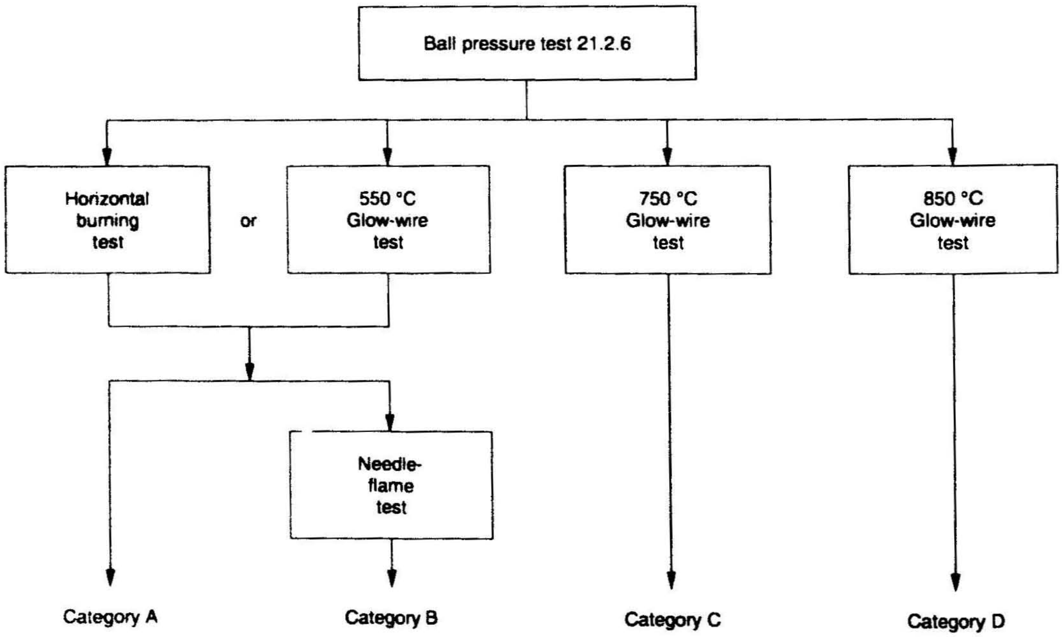
F.2 Category A controls have a rating of less than 0,5 A or are suitable for use in appliances having a rating of less than 0,5 A or are for hand-held appliances, appliances kept switched on by hand, or continuously loaded by hand.

F.3 Category B controls are suitable for use as an alternative to categories C or D.

F.4 Category C controls are suitable for use in appliances which are operated while attended and which have a current rating greater than 0,5 A.

F.5 Category D controls are suitable for use in appliances which are operated while unattended and which have a current rating greater than 0,5 A.

Parts of insulating material retaining connections in position



Annex G
(normative)

Heat and fire resistance tests

G.1 Burning test

The burning test is made on a specially prepared sample having a thickness of (3 ± 0,2) mm in accordance with IEC 60707.

For the purpose of this standard, method FH, Flame-Horizontal specimen, is used.

For the evaluation of the test results, category FH-3 applies, the maximum burning rate being 40 mm/min.

If more than one specimen do not withstand the test, the material is rejected.

If one specimen does not withstand the test, the test is repeated on another set of five specimens, all of which shall withstand the test.

G.2 Glow-wire test

The glow-wire test is made in accordance with IEC 60695-2-1.

The glow-wire test shall, if possible, be carried out on a complete control. If this is not possible, parts of the control may be removed to allow the tests to be carried out.

For the purpose of this standard, the following applies:

- *In clause 4, Description of the test apparatus, the first paragraph on page 11 is replaced by:*

  "In cases where burning or glowing particles might fall from the complete control onto an external surface underneath, the test is made while a piece of white pinewood board, approximately 10 mm thick and covered with a single layer of tissue paper, is positioned at a distance of (200 ± 5) mm below the place where the tip of the glow-wire is applied to the specimen."
- *In clause 5, Severities, the duration of application of the tip of the glow-wire to the specimen is (30 ± 1) s.*
- *In clause 10, Observations and measurements, item c) shall be recorded.*

G.3 Needle-flame test

The needle-flame test is made in accordance with IEC 60695-2-2.

For the purpose of this standard, the following applies:

- *In clause 4, Description of test apparatus, the sixth paragraph is replaced by:*

  "In cases where burning or glowing particles might fall from the complete control onto an external surface underneath, the test is made while a piece of white pinewood board, approximately 10 mm thick and covered with a single layer of tissue paper, is positioned at a distance of (200 ± 5) mm below the place where the test flame is applied to the specimen.

If the specimen is a complete control, the control itself, in its normal position of use, is placed on, or mounted above, the pinewood board covered with a single layer of tissue paper. Before starting the test, the board is conditioned as described in clause 6 for the specimen."

- *In clause 5, Severities, the duration of application of the test flame is (30 ± 1) s.*
- *In clause 8, Test procedure, the words in 8.4 "or from any source of ignition accidentally applied" do not apply.*

  Moreover, the last paragraph on page 11 and the first paragraph on page 13 are replaced by:

  "At the beginning of the test, the test flame is applied in such a way that at least the tip of the flame is in contact with the surface of the specimen. During application of the flame, the burner shall not be moved. The test flame is removed immediately after the specified period of time has elapsed. For examples of test positions, see figure 1, page 16."
- *In clause 8, Test procedure, 8.5 is replaced by:*

  "The test is made on one specimen. If the specimen does not withstand the test, the test is repeated on two further specimens, both of which shall then withstand the test."
- *In clause 10, Evaluation of test results, the following applies in addition:*

  "When a layer of tissue paper is used, there shall be no ignition of the tissue paper or scorching of the pinewood board, a slight discoloration of the pinewood board being neglected."

G.4 Proof tracking test

The proof tracking test is made in accordance with IEC 60112.

For the purpose of this standard, the following applies:

- *In clause 3, Test specimen, the last sentence of the first paragraph does not apply.*

  Moreover, notes 2 and 3 also apply to the proof tracking test of 6.3.
- *In clause 5, Test apparatus, the note in 5.1 does not apply.*

  Moreover, note 4 in 5.3 does not apply and the test solution A described in 5.4 is used.
- *In clause 6, Procedure, the voltage referred to in 6.1 is set to the value specified for the test voltage in 30.5.*

  Moreover, 6.2 does not apply and the proof tracking test of 6.3 is made five times.

Annex H
(normative)

Requirements for electronic controls

This annex supplements or modifies the corresponding clauses of this standard.

H.2 Definitions

H.2.4 Definitions relating to disconnection and interruption

H.2.4.2 *Addition:*

An electronic device does not provide this disconnection.

H.2.4.3 *Addition:*

An electronic device does not provide this disconnection.

H.2.4.4 *Addition:*

An electronic device does not provide this disconnection.

Add the following definition:

H.2.4.6
electronic disconnection
a non-cycling interruption by an electronic device of a circuit for functional disconnection and which provides a disconnection other than by means of an air gap by satisfying certain electrical requirements in at least one pole

Electronic disconnection ensures that, for all non-sensing controls, the function controlled by the disconnection is secure and that, for all sensing controls, the function controlled is secure between the limits of the activating quantity declared in table 7.2, requirement 36.

The disconnection may be obtained by an automatic action or a manual action.

Some controls may incorporate circuit disconnections of more than one form.

Electronic disconnection may not be suitable for some applications. See clause H.28.

H.2.5 Definitions of type of control according to construction

Add the following definitions:

H.2.5.7
electronic control
a control which incorporates at least one electronic device

H.2.5.8
electronic device
a device which produces a dynamic imbalance of electrons

The essential function and construction are based on semi-conductor device, vacuum tube or gas discharge tube technology.

H.2.5.9

electronic assembly

a group of components, at least one of which is an electronic device, but in which individual parts may be replaced without damage to the assembly

An example of this is a group of components mounted on a printed circuit board.

H.2.5.10

integrated circuit

an electronic device contained within the bulk of a semi-conductor material and interconnected at or near the surface of that material

The semi-conductor material is normally enclosed within some form of encapsulation.

H.2.7 Definitions relating to protection against electric shock

Add the following definition:

H.2.7.14

protective impedance

an impedance connected between live parts and accessible conductive parts, of such value that the current, in normal use and under likely fault conditions in the equipment, is limited to a safe value

Add the following definitions:

H.2.16 Definitions relating to the structure of controls using software

H.2.16.1

dual channel

a structure which contains two mutually independent functional means to execute specified operations

Special provision may be made for control of common mode fault/errors. It is not required that the two channels each be algorithmic or logical in nature.

H.2.16.2

dual channel (diverse) with comparison

a dual channel structure containing two different and mutually independent functional means, each capable of providing a declared response, in which comparison of output signals is performed for fault/error recognition

H.2.16.3

dual channel (homogeneous) with comparison

a dual channel structure containing two identical and mutually independent functional means, each capable of providing a declared response, in which comparison of internal signals or output signals is performed for fault/error recognition

H.2.16.4

single channel

a structure in which a single functional means is used to execute specified operations

H.2.16.5
single channel with functional test
a single channel structure in which test data is introduced to the functional unit prior to its operation

H.2.16.6
single channel with periodic self test
a single channel structure in which components of the control are periodically tested during operation

H.2.16.7
single channel with periodic self test and monitoring
a single channel structure with periodic self test in which independent means, each capable of providing a declared response, monitor such aspects as safety-related timing, sequences and software operations

H.2.17 Definitions relating to error avoidance in controls using software

black box test (see H.2.17.8.1)

H.2.17.1
dynamic analysis
a method of analysis in which inputs to a control are simulated and logic signals at the circuit nodes are examined for correct value and timing

H.2.17.2
failure rate calculation
a calculation of the theoretical number of failures of a given kind per unit

For example, failures per hour or failures per cycle of operation.

H.2.17.3
hardware analysis
an evaluation process in which the circuitry and components of a control are examined for correct function within their specified tolerances and ratings

H.2.17.4
hardware simulation
a method of analysis in which circuit function and component tolerances are examined by use of a computer model

H,2.17.5
inspection
an evaluation process in which the hardware or the software specification, design or code is examined in detail by a person or group other than the designer or programmer in order to identify possible errors

In contrast to the walk-through, the designer or programmer is passive during this evaluation.

H.2.17.6
operational test
an evaluation process in which a control is operated under the extremes of its intended operating conditions (e.g., cycle rate, temperature, voltage) to detect errors in design or construction

software fault/error detection time (see H.2.17.10)

H.2.17.7 Static analysis

H.2.17.7.1

static analysis – hardware

an evaluation process in which a hardware model is systematically assessed

The evaluation may typically be computer-aided and may include examination of parts lists and circuit layouts, an interface analysis and functional checks.

H.2.17.7.2

static analysis – software

an evaluation process in which a software programme is systematically assessed without necessarily executing the programme

The evaluation may typically be computer-aided and usually includes analysis of such features as programme logic, data paths, interfaces and variables.

H.2.17.8

systematic test

a method of analysis in which a system or a software programme is assessed for correct execution by the introduction of selected test data

For example see black box test and white box test.

H.2.17.8.1

black box test

a systematic test in which test data derived from the functional specification is introduced to a functional unit to assess its correct operation

H.2.17.8.2

white box test

a systematic test in which test data based on the software specification is introduced to a programme to assess the correct operation of subparts of the programme

For example, data may be selected to execute as many instructions as possible, as many branches as possible, as many subroutines as possible, etc.

H.2.17.9

walk-through

an evaluation process in which a designer or programmer leads members of an evaluation team through the hardware design, software design and/or software code the designer or programmer has developed in order to identify possible errors

In contrast to the inspection, the designer or programmer is active during this review.

white box test (see H.2.17.8.2)

H.2.17.10

software fault/error detection time

the period of time between the occurrence of a fault/error and the initiation by the software of a declared control response

H.2.18 Definitions relating to fault/error control techniques for controls using software

H.2.18.1 Bus redundancy

H.2.18.1.1
full bus redundancy
a fault/error control technique in which full redundant data and/or address are provided by means of redundant bus structure

H.2.18.1.2
multi-bit bus parity
a fault/error control technique in which the bus is extended by two or more bits and these additional bits are used for error detection

H.2.18.1.3
single bit bus parity
a fault/error control technique in which the bus is extended by one bit and this additional bit is used for error detection

H.2.18.2
code safety
fault/error control techniques in which protection against coincidental and/or systematic errors in input and output information is provided by the use of data redundancy and/or transfer redundancy (see also H.2.18.2.1 and H.2.18.2.2)

H.2.18.2.1
data redundancy
a form of code safety in which the storage of redundant data occurs

H.2.18.2.2
transfer redundancy
a form of code safety in which data is transferred at least twice in succession and then compared

This technique will recognize intermittent errors.

H.2.18.3
comparator
a device used for fault/error control in dual channel structures. The device compares data from the two channels and initiates a declared response if a difference is detected

H.2.18.4
d.c. fault model
a stuck-at fault model incorporating short circuits between signal lines

Because of the number of possible shorts in the device under test, usually only shorts between related signal lines will be considered. A logical signal level is defined, which dominates in cases where the lines try to drive to the opposite level.

H.2.18.5
equivalence class test
a systematic test intended to determine whether the instruction decoding and execution are performed correctly. The test data is derived from the CPU instruction specification

Similar instructions are grouped and the input data set is subdivided into specific data intervals (equivalence classes). Each instruction within a group processes at least one set of test data, so that the entire group processes the entire test data set. The test data can be formed from the following:

- data from valid range
- data from invalid range
- data from the bounds
- extreme values and their combinations

The tests within a group are run with different addressing modes, so that the entire group executes all addressing modes.

H.2.18.6
error recognizing means
independent means provided for the purpose of recognizing errors internal to the system

Examples are monitoring devices, comparators, and code generators.

full bus redundancy (see H.2.18.1.1).

frequency monitoring (see H.2.18.10.1)

H.2.18.7
hamming distance
a statistical measure, representing the capability of a code to detect and correct errors. The hamming distance of two code words is equal to the number of positions different in the two code words

H. Holscher and J. Rader; "Microcomputers in safety techniques." Verlag TUV Bayern. TUV Rheinland. (ISBN 3-88585-315-9).

H.2.18.8
input comparison
Aa fault/error control technique by which inputs that are designed to be within specified tolerances are compared

H.2.18.9
internal error detecting or correcting
a fault/error control technique in which special circuitry is incorporated to detect or correct errors

logical monitoring of the programme sequence (see H.2.18.10.2)

multi-bit bus parity (see H.2.18.1.2)

H.2.18.10 Programme sequence

H.2.18.10.1
frequency monitoring
a fault/error control technique in which the clock frequency is compared with an independent fixed frequency

An example is comparison with the line supply frequency.

H.2.18.10.2
logical monitoring of the programme sequence
a fault/error control technique in which the logical execution of the programme sequence is monitored

Examples are the use of counting routines or selected data in the programme itself or by independent monitoring devices.

H.2.18.10.3

time-slot and logical monitoring

this is a combination of H.2.18.10.2 and H.2.18.10.4

H.2.18.10.4

time-slot monitoring of the programme sequence

a fault/error control technique in which timing devices with an independent time base are periodically triggered in order to monitor the programme function and sequence

An example is a watchdog timer.

H.2.18.11

multiple parallel outputs

a fault/error control technique in which independent outputs are provided for operational error detection or for independent comparators

H.2.18.12

output verification

a fault/error control technique in which outputs are compared to independent inputs

This technique may or may not relate an error to the output which is defective.

H.2.18.13

plausibility check

a fault/error control technique in which programme execution, inputs or outputs are checked for inadmissible programme sequence, timing or data

Examples are the introduction of an additional interrupt after completion of a certain number of cycles or checks for division by zero.

H.2.18.14

protocol test

a fault/error control technique in which data is transferred to and from computer components to detect errors in the internal communications protocol

H.2.18.15

reciprocal comparison

a fault/error control technique used in dual channel (homogeneous) structures in which a comparison is performed on data reciprocally exchanged between the two processing units

Reciprocal refers to an exchange of similar data.

H.2.18.16

redundant data generation

the availability of two or more independent means, such as code generators, to perform the same task

H.2.18.17
redundant monitoring
the availability of two or more independent means such as watchdog devices and comparators to perform the same task

H.2.18.18
scheduled transmission
a communication procedure in which information from a particular transmitter is allowed to be sent only at a predefined point in time and sequence, otherwise the receiver will treat it as a communication error

single bit bus parity (see H.2.18.1.3)

H.2.18.19
software diversity
a fault/error control technique in which all or parts of the software are incorporated twice in the form of alternate software code

For example, the alternate forms of software code may be produced by different programmers, different languages or different compiling schemes and may reside in different hardware channels or in different areas of memory within a single channel.

H.2.18.20
stuck-at fault model
a fault model representing an open circuit or a non-varying signal level

These are usually referred to as "stuck open", "stuck at 1" or "stuck at 0".

H.2.18.21
tested monitoring
the provision of independent means such as watchdog devices and comparators which are tested at start-up or periodically during operation

H.2.18.22
testing pattern
a fault/error control technique used for periodic testing of input units, output units and interfaces of the control. A test pattern is introduced to the unit and the results compared to expected values. Mutually independent means for introducing the test pattern and evaluating the results are used. The test pattern is constructed so as not to influence the correct operation of the control

time-slot and logical monitoring (see H.2.18.10.3)

time-slot monitoring of the programme sequence (see H.2.18.10.4)

transfer redundancy (see H.2.18.2.2)

H.2.19 Definitions relating to memory tests for controls using software

H.2.19.1
Abraham test
a specific form of a variable memory pattern test in which all stuck-at and coupling faults between memory cells are identified

The number of operations required to perform the entire memory test is about 30 n, where n is the number of cells in the memory. The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments.

Abraham, J.A.; Thatte, S.M.; "Fault coverage of test programs for a microprocessor", Proceedings of the IEEE Test Conference 1979, pp 18-22.

H.2.19.2
GALPAT memory test

a fault/error control technique in which a single cell in a field of uniformly written memory cells is inversely written, after which the remaining memory under test is inspected. After each read operation to one of the remaining cells in the field, the inversely written cell is also inspected and read. This process is repeated for all memory cells under test. A second test is then performed as above on the same memory range without inverse writing to the test cell

The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments (see transparent GALPAT test).

H.2.19.2.1
transparent GALPAT test

a GALPAT memory test in which first a signature word is formed representing the content of the memory range to be tested and this word is saved. The cell to be tested is inversely written and the test is performed as above. However, the remaining cells are not inspected individually, but by formation of and comparison to a second signature word. A second test is then performed as above by inversely writing the previously inverted value to the test cell

This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

checkerboard memory test (see H.2.19.6.1)

H.2.19.3 Checksum

H.2.19.3.1
modified checksum

a fault/error control technique in which a single word representing the contents of all words in memory is generated and saved. During self test, a checksum is formed from the same algorithm and compared with the saved checksum

This technique recognizes all the odd errors and some of the even errors.

H.2.19.3.2
multiple checksum

a fault/error control technique in which a separate words representing the contents of the memory areas to be tested are generated and saved. During self test, a checksum is formed from the same algorithm and compared with the saved checksum for that area

This technique recognizes all the odd errors and some of the even errors.

H.2.19.4 Cyclic redundancy check (CRC)

H.2.19.4.1
CRC – single word

a fault/error control technique in which a single word is generated to represent the contents of memory. During self test the same algorithm is used to generate another signature word which is compared with the saved word

This technique recognizes all one-bit, and a high percentage of multi-bit, errors.

H.2.19.4.2

CRC – double word

a fault/error control technique in which at least two words are generated to represent the contents of memory. During self test the same algorithm is used to generate the same number of signature words which are compared with the saved words

This technique can recognize one-bit and multi-bit errors with a greater accuracy than in CRC – single word.

marching memory test (see H.2.19.6.2)

modified checksum (see H.2.19.3.1)

multiple checksum (see H.2.19.3.2)

H.2.19.5

redundant memory with comparison

a structure in which the safety-related contents of memory are stored twice in different format in separate areas so that they can be compared for error control

H.2.19.6

static memory test

a fault/error control technique which is intended to detect only static errors

H.2.19.6.1

checkerboard memory test

a static memory test in which a checkerboard pattern of zeros and ones is written to the memory area under test and the cells are inspected in pairs. The address of the first cell in each pair is variable and the address of the second cell is derived from a bit inversion of the first address. In the first inspection, the variable address is first incremented to the end of the address space of the memory and then decremented to its original value. The test is repeated with the checkerboard pattern inversed

H.2.19.6.2

marching memory test

a static memory test in which data is written to the memory area under test as in normal operation. Every cell is then inspected in ascending order and a bit inversion performed on the contents. The inspection and bit inversion are then repeated in descending order. Then this process is repeated after first performing a bit inversion on all the memory cells under test

transparent GALPAT test (see H.2.19.2.1)

H.2.19.7

walkpat memory test

a fault/error control technique in which a standard data pattern is written to the memory area under test as in normal operation. A bit inversion is performed on the first cell and the remaining memory area is inspected. Then the first cell is again inverted and the memory inspected. This process is repeated for all memory cells under test. A second test is conducted by performing a bit inversion of all cells in memory under test and proceeding as above

This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

H.2.19.8 Word protection

H.2.19.8.1

word protection with multi-bit redundancy

a fault/error control technique in which redundant bits are generated and saved for each word in the memory area under test. As each word is read, a parity check is conducted

An example is a hamming code which recognizes all one and two bit errors as well as some three bit and multi-bit errors.

H.2.19.8.2

word protection with single bit redundancy

a fault/error control technique in which a single bit is added to each word in the memory area under test and saved, creating either even parity or odd parity. As each word is read, a parity check is conducted

This technique recognizes all odd bit errors.

H.2.20 Definitions of software terminology – General

H.2.20.1

common mode error

error(s) in a dual channel or other redundant structure such that each channel or structure is affected simultaneously and in the same manner

H.2.20.2

failure modes and effects analysis (FMEA)

analytical technique in which the failure modes of each hardware component are identified and examined for their effects on the safety-related functions of the control

H.2.20.3

independent

not being adversely influenced by the control data flow and not being impaired by failure of other control functions, or by common mode effects

H.2.20.4

invariable memory

memory ranges in a processor system containing data which is not intended to vary during programme execution

Invariable memory may include RAM construction where the data is not intended to vary during programme execution.

H.2.20.5

variable memory

memory ranges in a processor system containing data which is intended to vary during programme execution

H.4 General notes on tests

H.4.1 Conditions of test

H.4.1.4 *Addition:*

For electronic controls, the tests of clauses H.25, H.26 and H.27 are carried out before the tests of clause 21.

Additional subclauses:

H.4.1.9 *Electronic controls shall be tested as electrical controls, unless otherwise specified.*

H.4.1.10 *When conducting the test sequence for electronic controls, care shall be taken that the results of a test are not influenced adversely by any preceding testing of the sample unless specifically required by the standard. It may be necessary to replace that sample, or parts thereof, or to use an additional sample.*

The number of samples should be kept to the minimum by an evaluation of the relevant circuits.

H.4.1.11 *Except for the test specified in clause H.26, care shall be taken that the supply is free of such perturbations from external sources as may influence the results of the tests on electronic controls.*

H.6 Classification

H.6.4 According to features of automatic action

H.6.4.3 *Additional subclause:*

H.6.4.3.13 – electronic disconnection on operation (Type 1.Y – 2.Y)

H.6.9 According to circuit disconnection or interruption:

Addition:

H.6.9.5 – electronic disconnection

H.6.18 According to software class

H.6.18.1 – Software class A

H.6.18.2 – Software class B

H.6.18.3 – Software class C

Within a control, different software classes may apply to particular software segments.

See note 17 of table 7.2.

H.7 Information

Additional items to table 7.2 12)

Information		Clause or subclause	Method
Modification:			
36	Limits of activating quantity for any sensing element over which micro-disconnection or electronic disconnection is secure	H.11.3.2, H.11.4.16, H.17.14, H.18.1.5, H.27.1, H.28	X
Additional items to table 7.2:			D
52	The minimum parameters of any heat dissipator (e.g. heat sink) not provided with an electronic control but essential to its correct operation	14	
53	Type of output waveform if other than sinusoidal	H.25	X
54	Details of the leakage current waveform produced after failure of the basic insulation	H.27	X
55	The relevant parameters of those electronic devices or other circuit components considered as unlikely to fail (see paragraph 1 of H.27.1.3.1)	H.27	X
56	Type of output waveform(s) produced after failure of an electronic device or other circuit component (see item g) of H.27.1.3)	H.27	X
57	The effect on controlled output(s) after electronic circuit component failure if relevant (item c) of H.27.1.3)	H.27	X
58a	For integrated and incorporated electronic controls, if any protection against mains borne perturbations, magnetic and electromagnetic disturbances is claimed, which of the tests of clause H.26 shall be performed and the effect on controlled output(s) and function after a failure to operate as a result of each test	H.26.2 H.26.13	X
58b	For other than integrated and incorporated electronic controls, the effect on controlled output(s) and function after a failure to operate as a result of the tests of clause H.26	H.26.2 H.26.13	X
59	Any component on which reliance is placed for electronic disconnection which is disconnected as required by note 14 to table 13.2	13.2 H.27.1	X
60	Category (surge immunity)	H.26.8.4 H.26.10.4	X
66	Software sequence documentation 12) 13) 15) 18)	H.11.12.10	X
67	Programme documentation 12) 14) 18)	H.11.12.10 H.11.12.13	X
68	Software fault analysis 12) 15) 18)	H.11.12 H.27.1.3.1	X
69	Software class(es) and structure 17)	H.6.18 H.11.12.2	D
70	Analytical measures and fault/error control techniques employed 12) 16)	H.11.12.2 H.11.12.4 H.11.12.7	X
71	Software fault/error detection time(s) for controls of software classes B or C 12) 19)	H.2.17.10 H.11.12.8	X
72	Control response(s) in case of detected fault/error 12)	H.11.12.8.1	X
73	Controls subjected to a second fault analysis and declared condition as a result of the second fault	H.27.1.3	X
74	External load and emission control measures to be used for test purposes	H.23.1.1	X

Additional items to table 7.2 (concluded)

[12] For controls declared as entirely software class A, the information in requirements 66, 67, 68, 70, 71 and 72 is not required. For controls declared as software classes B or C, information shall be provided only for the safety-related segments of the software. Information on the non-safety related segments shall be sufficient to establish that they do not influence the safety-related segments.

[13] The software sequence shall be documented and, together with the operating sequence of table 7.2 requirement 46, shall include a description of the control system philosophy, the control flow, data flow and the timings.

[14] Programming documentation shall be supplied in a programming design language declared by the manufacturer.

[15] Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of 17, 25, 26 and 27, shall be identified. This identification shall include the operating sequence and may, for example, take the form of a fault tree analysis which shall include those fault/errors of table H.11.12.7 which could result in non-compliance. The software fault analysis shall be related to the hardware fault analysis in H.27.

[16] Measures to be declared are those chosen by the manufacturer from the requirements of H.11.12.2 to H.11.12.7 inclusive.

[17] Within a control, different software classes may apply to different control functions. Examples of control functions that may be classified under software classes A to C are as follows:

Class A

Control functions which are not intended to be relied upon for the safety of the equipment.

Examples of controls which may include class A functions are: room thermostats, humidity controls, lighting controls, timers and time switches.

Class B

Control functions intended to prevent unsafe operation of the controlled equipment.

Examples of controls which may include Class B functions are: thermal cut-outs and door locks for laundry equipment.

Class C

Control functions which are intended to prevent special hazards (e.g., explosion of the controlled equipment).

Examples of controls which may include class C functions are: automatic burner controls and thermal cut-outs for closed water heater systems (unvented).

[18] Examples of other information which may be suitable for inclusion in the documentation required by notes 12) to 17) are:

Original software system specification, for example:

Functional specification, including procedure for restart on loss of supply

Module design, including description of equipment interfaces, and description of user interfaces

Detailed design, including description of use of memory

Code listing, including programming language identification, comments and listing of subroutines

Test specification

Manuals for installation, use and/or maintenance

[19] This can be expressed as a time following the execution of a specific software segment.

H.8 Protection against electric shock

H.8.1 General requirements

Additional subclauses:

H.8.1.10 Accessible parts shall not be considered as live parts if separated from the supply by protective impedance.

H.8.1.10.1 When protective impedance is used, the current between the part or parts and either pole of the supply source shall not exceed 0,7 mA (peak value) a.c. or 2 mA d.c.;

- for frequencies exceeding 1 kHz, the limit of 0,7 mA (peak value) is multiplied by the value of the frequency in kHz but shall not exceed 70 mA (peak value);
- for voltages over 42,4 V (peak value) and up to and including 450 V (peak value) the capacitance shall not exceed 0,1 µF;
- for voltages over 450 V (peak value) and up to and including 15 kV (peak value) the product of the capacitance in microfarads times the potential in volts shall not exceed 45 µC;
- for voltages over 15 kV (peak value) the product of the capacitance in microfarads times the square of the potential in volts shall not exceed 350 µJ.

Compliance is checked by measurement.

Voltages and currents are measured between a single accessible part (or any combination of such parts) and either pole of the supply source.

The measuring circuit shall have a total impedance of (1 750 ± 250) Ω and be shunted by a capacitor such that the time constant of the circuit is (225 ± 15) µs.

Details of a suitable circuit for measuring leakage currents are given in annex E.

The measuring circuit shall have an accuracy of within 5 % for all frequencies in the range of 20 Hz to 5 kHz. For frequencies above 5 kHz, alternative methods of measurement are required.

H.11 Constructional requirements

H.11.2 Protection against electric shock

Additional subclauses:

H.11.2.5 Protective impedance shall consist of two or more impedances in series provided exclusively for purposes of protection. It shall consist of components in which the probability of a reduction in impedance during life can be ignored. The series chain of impedances shall be connected between live parts and an accessible part and shall contain no electronic devices or interconnection to such devices.

The impedances used to provide protective impedance shall be resistors of the type where the possibility of a short circuit is negligible; e.g., oxide film, metal film, carbon film and single layer wirewound resistors having a coating such that movement of the wire is prevented if the wire becomes open-circuited. In addition, the resistors shall comply with the requirements of 14.1 of IEC 60065.

Compliance is checked by:

1) *short-circuiting and open-circuiting each impedance in turn;*
2) *applying a fault condition to any other part of the circuit which might influence the maximum leakage current with the two protective impedances intact, e.g., failure of any circuit component, operation of a protective device or loss of one pole of the supply.*

Under these conditions, the equipment shall still comply with the requirements of H.8.1.10.

H.11.4 Actions

Additional subclauses:

H.11.4.16 Type 1.Y or 2.Y action shall operate to provide electronic disconnection.

Compliance is checked by the tests of this subclause.

H.11.4.16.1 The test is carried out with the control connected to its declared maximum load, supplied with rated voltage, and at temperature T_{max}.

H.11.4.16.2 The current through the electronic disconnection shall not exceed 5 mA or 10 % of the rated current, whichever is the lower.

H.11.12 Controls using software

Controls using software shall be so constructed that the software does not impair control compliance with the requirements of this standard.

Compliance is checked by the tests for electronic controls in this standard, by inspection according to the requirements of this subclause and by examination of the documentation required in items 66 to 72 inclusive of table 7.2

H.11.12.1 to **H.11.12.13** inclusive are not applicable to control functions classified as software class A.

H.11.12.1 Controls with functions classified as software class B or C shall use measures to avoid and control software-related faults/errors in safety-related data and safety-related segments of the software, as detailed in H.11.12.2 to H.11.12.13 inclusive.

H.11.12.2 Controls with functions declared as software class C shall have one of the following structures:

- single channel with periodic self-test and monitoring (H.2.16.7);
- dual channel (homogenous) with comparison (H.2.16.3);
- dual channel (diverse) with comparison (H.2.16.2).

Comparison between dual channel structures may be performed:

- by the use of a comparator (H.2.18.3) or
- by reciprocal comparison (H.2.18.15).

Controls with functions declared as software class B shall have one of the following structures:

- single channel with functional test (H.2.16.5);
- single channel with periodic self-test (H.2.16.6);

– dual channel without comparison (H.2.16.1).

Software class C structures are also acceptable for software Class B controls.

H.11.12.2.1 Other structures are permitted if they can be shown to provide an equivalent level of safety to those in H.11.12.2.

H.11.12.3 When redundant memory with comparison is provided on two areas of the same component, the data in one area shall be stored in a different format from that in the other area (see software diversity).

H.11.12.4 Controls with functions declared as software class C using dual channel structures with comparison shall have additional fault/error detection means (such as periodic functional tests, periodic self tests, or independent monitoring) for any fault/errors not detected by the comparison.

H.11.12.5 For controls with functions other than software class A, means shall be provided for the recognition and control of errors in transmissions to external safety-related data paths. Such means shall take into account errors in data, addressing, transmission timing and sequence of protocol.

H.11.12.6 For controls with functions declared as software class C, the manufacturer shall have used one of the combinations (a–p) of analytical measures given in the columns of table H.11.12.6 during hardware development.

This is not applicable to dual-channel systems using diverse hardware with comparison (H.2.16.2), except to check for the possibility of common mode errors.

In the USA the preceding explanatory paragraph is not applicable.

Table H.11.12.6 – Combinations of analytical measures during hardware development

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
H.2.17.5 Inspection	x		x		x		x		x		x		x		x	
H.2.17.9 Walk-through				x		x		x		x		x		x		x
H.2.17.7.1 Static analysis	x	x							x	x						
H.2.17.1 Dynamic analysis			x	x							x	x				
H.2.17.3 Hardware analysis					x	x							x	x		
H.2.17.4 Hardware simulation							x	x							x	x
H.2.17.2 Failure rate calculation	x	x	x	x	x	x	x	x								
H.2.20.2 FMEA									x	x	x	x	x	x	x	x
H.2.17.6 Operational test	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

H.11.12.6.1 For controls with functions declared as software class C, the manufacturer shall have used systematic test (H.2.17.8) and inspection (H.2.17.5) or walk-through (H.2.17.9) or static analysis (H.2.17.7.2) during software development.

H.11.12.7 For control functions other than software class A, the manufacturer shall provide, within the control, measures to address the fault/errors in safety-related segments and data indicated in table H.11.12.7 and identified in table 7.2, requirement 68.

Table H.11.12.7 [6)]

Component [1)]	Fault/error	Software class		Acceptable measures [2) 3) 4)]	Definitions
		B	C		
1. CPU					
1.1					
Registers	Stuck at	rq		Functional test, or	H.2.16.5
				periodic self-test using either:	H.2.16.6
				– static memory test, or	H.2.19.6
				– word protection with single bit redundancy	H.2.19.8.2
	DC fault		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				Internal error detection, or	H.2.18.9
				redundant memory with comparison, or	H.2.19.5
				periodic self-tests using either	
				– walkpat memory test	H.2.19.7
				– Abraham test	H.2.19.1
				– transparent GALPAT test; or	H.2.19.2.1
				word protection with multi-bit redundancy, or	H.2.19.8.1
				static memory test and word protection	H.2.19.6
				with single bit redundancy	H.2.20.8.2
1.2					
Instruction decoding and execution	Wrong decoding and execution		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				internal error defection, or	H.2.18.9
				periodic self-test using equivalence class test	H.2.18.5
1.3					
Programme counter	Stuck at	rq		Functional test, or	H.2.16.5
				periodic self-test, or	H.2.16.6
				independent time-slot monitoring, or	H.2.18.10.4
				logical monitoring of the programme sequence	H.2.18.10.2
	DC fault		rq	Periodic self-test and monitoring using either:	H.2.16.7
				– independent time-slot and logical monitoring	H.2.18.10.3
				– internal error detection, or	H.2.18.9
				comparison of redundant functional channels by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator	H.2.18.3
1.4					
Addressing	DC fault		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator; or	H.2.18.3
				Internal error detection; or	H.2.18.9
				periodic self-test using a testing pattern of	H.2.16.7
				the address lines; or	H.2.18.22
				full bit bus parity including the address	H.2.18.1.1
					H.2.18.1.2

Table H.11.12.7 *(continued)* [6]

Component [1]	Fault/error	Software class		Acceptable measures [2][3][4]	Definitions
		B	C		
1.5 Data paths instruction decoding	DC fault and execution		rq	Comparison of redundant CPUs by either	
				reciprocal comparison, or	H.2.18.15
				independent hardware comparator, or	H.2.18.3
				Internal error detection, or	H.2.18.9
				periodic self-test using a testing pattern, or	H.2.16.7
				data redundancy, or	H.2.18.22
				multi-bit bus parity	H.2.18.1.2
2. Interrupt handling and execution	No interrupt or too frequent interrupt	rq		Functional test; or	H.2.16.5
				time-slot monitoring	H.2.18.10.4
	No interrupt or too frequent interrupt related to different sources		rq	Comparison of redundant functional channels by either	
				reciprocal comparison,	H.2.18.15
				independent hardware comparator, or	H.2.18.3
				Independent time-slot and logical monitoring	H.2.18.10.3
3. Clock		rq		Frequency monitoring, or	H.2.18.10.1
				time slot monitoring	H.2.18.10.4
	Wrong frequency (for quartz synchronized clock: harmonics/subharmonics only)		rq	Frequency monitoring, or	H.2.18.10.1
				time-slot monitoring, or	H.2.18.10.4
				comparison of redundant functional channels by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator	H.2.18.3
4. Memory 4.1 Invariable memory	All single bit faults	rq		Periodic modified checksum; or	H.2.19.3.1
				multiple checksum, or	H.2.19.3.2
				word protection with single bit redundancy	H.2.19.8.2
	99,6 % coverage of all information errors		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				redundant memory with comparison, or	H.2.19.5
				periodic cyclic redundancy check, either	
				– single word	H.2.19.4.1
				– double word, or	H.2.19.4.2
				word protection with multi-bit redundancy	H.2.19.8.1

Table H.11.12.7 *(continued)* 6)

Component 1)	Fault/error	Software class		Acceptable measures 2) 3) 4)	Definitions
		B	C		
4.2 Variable memory	DC fault	rq		Periodic static memory test, or	H.2.19.6
				word protection with single bit redundancy	H.2.19.8.2
	DC fault and dynamic cross links		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				redundant memory with comparison, or	H.2.19.5
				periodic self tests using either:	
				– walkpat memory test	H.2.19.7
				– Abraham test	H.2.19.1
				– transparent GALPAT test, or	H.2.19.2.1
				word protection with multi-bit redundancy	H.2.19.8.1
4.3 Addressing (relevant to variable and invariable memory)	Stuck at	rq		Word protection with single bit parity including the address, or	H.2.19.18.2
	DC fault		rq	comparison of redundant CPUs by either:	
				– reciprocal comparison, or	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				full bus redundancy	H.2.18.1.1
				Testing pattern, or	
				periodic cyclic redundancy check, either:	H.2.18.22
				– single word	H.2.19.4.1
				– double word, or	H.2.19.4.2
				word protection with multi-bit redundancy including the address	H.2.19.8.1
5. Internal data path	Stuck at	rq		Word protection with single bit redundancy	H.2.19.8.2
	DC fault		rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
5.1 Data				word protection with multi-bit redundancy	H.2.19.8.1
				including the address, or data redundancy, or	H.2.18.2.1
				testing pattern, or	H.2.18.22
				protocol test	H.2.18.14
5.2 Addressing	Wrong address	rq		Word protection with single bit redundancy including the address	H.2.19.8.2
	Wrong address and multiple addressing		rq	Comparison of redundant CPUs by:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				word protection with multi-bit redundancy, including the address, or full bus redundancy; or testing pattern including the address	H.2.19.8.1 H.2.18.1.1 H.2.18.22

Table H.11.12.7 *(continued)* 6)

Component 1)	Fault/error	Software class		Acceptable measures 2) 3) 4)	Definitions
		B	C		
6 External communication	Hamming distance 3	rq		Word protection with multi-bit redundancy, or CRC – single word , or	H.2.19.8.1 H.2.19.4.1
				transfer redundancy, or	H.2.18.2.2
				protocol test	H.2.18.14
6.1 Data	Hamming distance 4		rq	CRC – double word, or	H.2.19.4.2
				data redundancy or comparison of redundant functional channels by either:	H.2.18.2.1
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator	H.2.18.3
6.2 Addressing	Wrong address		rq	Word protection with multi-bit redundancy,	H.2.19.8.1
				including the address, or CRC single word	H.2.19.4.1
				including the addresses, or	
				transfer redundancy or	H.2.18.2.2
				protocol test	H.2.18.14
	Wrong and multiple addressing		rq	CRC – double word, including the address, or	H.2.19.4.2
				full bus redundancy of data and address, or	H.2.18.1.1
				comparison of redundant communication channels by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator	H.2.18.3
6.3 Timing	Wrong point in time	rq		Time-slot monitoring, or scheduled transmission	H.2.18.10.4 H.2.18.18
		rq		Time-slot and logical monitoring, or	H.2.18.10.3
				comparison of redundant communication channels by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator	H.2.18.3
	Wrong sequence	rq		Logical monitoring, or	H.2.18.10.2
				time-slot monitoring, or	H.2.18.10.4
				scheduled transmission	H.2.18.18
			rq	(same options as for wrong point in time)	
7. Input/output periphery	Fault conditions specified in H.27	rq		Plausibility check	H.2.18.13
			rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
7.1 Digital I/O				input comparison, or	H.2.18.8
				multiple parallel outputs; or	H.2.18.11
				output verification, or	H.2.18.12
				testing pattern, or	H.2.18.22
				code safety	H.2.18.2

Table H.11.12.7 (concluded) [6]

Component [1]	Fault/error	Software class		Acceptable measures [2] [3] [4]	Definitions
		B	C		
7.2 Analog I/O					
7.2.1 A/D- and D/A- convertor	Fault conditions specified in H.27	rq		Plausibility check	H.2.18.13
			rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				input comparison, or	H.2.18.8
				multiple parallel outputs, or	H.2.18.11
				output verification, or	H.2.18.12
				testing pattern	H.2.18.22
7.2.2 Analog multiplexer	Wrong addressing	rq		Plausibility check	H.2.18.13
			rq	Comparison of redundant CPUs by either:	
				– reciprocal comparison	H.2.18.15
				– independent hardware comparator, or	H.2.18.3
				input comparison or	H.2.18.8
				testing pattern	H.2.18.22
8. Monitoring devices and comparators	Any output outside the static and dynamic functional specification		rq	Tested monitoring, or	H.2.18.21
				redundant monitoring and comparison, or	H.2.18.17
				error recognizing means	H.2.18.6
9. Custom chips [5] e.g. ASIC, GAL, Gate array	Any output outside the static and dynamic functional specification	rq		Periodic self test	H.2.16.6
			rq	Periodic self-test and monitoring, or	H.2.16.7
				dual channel (diverse) with comparison, or	H.2.16.2
				error recognizing means	H.2.18.6

CPU:

rq: Coverage of the fault is required for the indicated software class.

[1] For fault/error assessment, some components are divided into their subfunctions.

[2] For each subfunction in the table, the software class C measure will cover the software class B fault/error.

[3] It is recognized that some of the acceptable measures provide a higher level of assurance than is required by this standard.

[4] Where more than one measure is given for a subfunction, these are alternatives.

[5] To be divided as necessary by the manufacturer into subfunctions.

[6] Table H.11.12.7 is applied according to the requirements of H.11.12 to H.11.12.13 inclusive.

H.11.12.7.1 Other measures are permitted if they can be shown to satisfy at least the minimum fault/error requirements of the acceptable measures in table H.11.12.7-1.

Table H.11.12.7-1 – Example of measures to control faults/errors in a single chip microcomputer (8 bit) (software class C, single channel with self-test and monitoring)

	Component/function	Examples of acceptable measures	Definition
1.1	CPU/registers	Periodic self-test using walkpat memory test	H.2.19.7
1.2	CPU/instruction decoding and execution	Periodic self-test using equivalence class test with values inside, outside and at the limits of the specified ranges: the instructions are grouped as follows: move instructions arithmetic instructions bit and shift instructions conditional instructions other instructions	H.2.18.5
1.3	CPU/programme counter	Independent time slot and logical monitoring	H.2.18.10.3
1.4	Addressing of variable memory	Periodic self-test using a testing pattern for address lines	H.2.18.22
5.2	Addressing of invariable memory	Covered by test of invariable memory, see 4.1	
	Addressing of I/O components	I/O address lines covered by I/O tests, see clause 7	
1.5	Data path to variable memory	Covered by test of variable memory see 4.2	
5.1	Data path to invariable memory invariable	Covered by test of invariable memory, see 4.1	
	Data path to I/O components	Covered by I/O tests, see clause 7	
2.	Interrupt handling and execution	Covered by test of 1.3	
3.	Clock	Frequency monitoring	H.2.18.10
4.1	Invariable memory, internal or external	CRC – single word (8 bits)	H.2.19.4.1
4.2	Variable memory, internal or external	Redundant memory with software comparison	H.2.19.5
6.	External communication, data and addressing	CRC – double word (16 bit) incorporating data, sources and destination addresses	H.2.19.4.2
6.3	Timing	Scheduled transmission	H.2.18.18
7.	Digital input Digital output	Testing pattern for inputs Output verification	H.2.18.22 H.2.18.12
7.2	Analog input, Multiplexer and A/D-converter	Input comparison (inverted polarity)	H.2.18.8
Other components external to the microcomputer			
8.	Monitoring device	Tested monitoring	H.2.18.21
9.	PLA (Programmable Logic Array)	Periodic self-test and monitoring	H.2.16.7

H.11.12.8 Software fault/error detection shall occur not later than the time declared in requirement 71 of table 7.2. The acceptability of the declared time(s) is evaluated during the fault analysis of the control.

Part 2 standards may limit this declaration.

H.11.12.8.1 For controls with functions other than software Class A, detection of a fault/error shall result in the response declared in table 7.2, requirement 72. For controls with functions declared as software class C, independent means capable of performing this response shall be provided.

H.11.12.9 The loss of dual channel capability is deemed to be an error in a control using a dual channel structure with functions declared as software class C.

H.11.12.10 The software shall be referenced to relevant parts of the operating sequence and the associated hardware functions.

H.11.12.11 Where labels are used for memory locations, these labels shall be unique.

H.11.12.12 The software shall be protected from user alteration of safety-related segments and data.

H.11.12.13 The software and safety-related hardware under its control shall be initialized to, and terminate at, a declared state as indicated in table 7.2, requirement 66.

H.13 Electric strength and insulation resistance

H.13.2 Electric strength

Addition to table 13.2 :

Across electronic disconnection [15]	*120*	*260*	*500*	*880*	*1 320*

Additional notes to table 13.2:

[11] Care should be taken when carrying out the tests to avoid overstressing the components of electronic controls.

[12] For accessible parts which are protected by means of protective impedance, the tests are carried out with the components disconnected, the mid-point of the two impedances being regarded as an intermediate metal part.

[13] Operational insulation on printed wiring boards submitted in normal use to a voltage up to 50 V is not subjected to the tests of this clause.

[14] See 13.2.

[15] The device which actually performs the disconnection is first removed from the circuit. If necessary, any control input is connected such that the device is providing the disconnection. The test voltage is then applied to the terminals and terminations of the device which carry the load current.

H.17 Endurance

H.17.1 General requirements

H.17.1.4 No endurance test is carried out on electronic controls with type 1 action unless this is necessary for the testing of associated components such as those with manual actions, relays, etc.

H.17.1.4.1 Electronic controls with type 2 action are not subjected to an endurance test but to a thermal cycling test under the conditions described in H.17.1.4.2. This test may be combined with the testing of any associated components such as those with manual actions, relays, etc., if this is possible.

H.17.1.4.2 Thermal cycling test

The purpose of the test is to cycle components of an electronic circuit between the extremes of temperature likely to occur during normal use and which may result from ambient temperature variation, mounting surface temperature variation, supply voltage variation, or the change from an operating condition to a non-operating condition and vice versa.

The tests necessary to achieve the above conditions will depend to a large extent on the particular type of control and will be expanded upon, if necessary, in the appropriate part 2 of this standard.

The following conditions shall form the basis of the test:

a) *Duration*

14 days, or any duration specified in the relevant part 2, whichever is the greater. For controls providing electronic disconnection (Type 1.Y or 2.Y), 14 days, or the number of cycles declared in requirements 26 and 27 of table 7.2, whichever produces the longer duration of test.

b) *Electrical conditions*

The control shall be loaded according to the ratings declared by the manufacturer, the voltage then being increased to 1,1 V_R *except for 30 min of each 24 h period of the test when the voltage is reduced to 0,9* V_R. *The change of voltage shall not be synchronized with the change of temperature. Each 24 h period shall also include at least one period in the order of 30 s during which the supply voltage is switched off.*

c) *Thermal conditions*

The ambient temperature and/or the mounting surface temperature are varied between T_{max} ($T_{s\ max}$) *and* T_{min} ($T_{s\ min}$) *to cause the temperature of the components of the electronic circuit to be cycled between the resulting extremes. The rate of ambient and/or mounting surface temperature change shall be in the order of 1 °C/min and the extremes of temperature maintained for approximately 1 h.*

d) *Rate of operation*

During the test, the control shall be cycled through its operational modes at the fastest rate possible up to a maximum of six cycles per minute, subject to the need to cycle components between their temperature extremes.

If an operational mode, such as speed control, can be set by the user, the test period shall be divided into three periods, one period being at the maximum, one at the minimum and one at an intermediate setting.

For controls providing electronic disconnection (Type 1.Y or 2.Y), the test also includes the declared number of operations from the conducting to the non-conducting state and vice versa.

H.17.14 Evaluation of compliance

Replacement of first paragraph:

After all the appropriate tests of 17.6 to 17.13 inclusive and H.17.1.4, modified as specified in the appropriate part 2, the control shall be deemed to comply if:

Additional dashed paragraph:

- For controls providing electronic disconnection (Type 1.Y or 2.Y), the requirements of H.11.4.16 are still met.

H.18 Mechanical strength

H.18.1 General requirements

H.18.1.5 *Addition:*

For controls providing electronic disconnection (Type 1.Y or 2.Y), the requirements of H.11.4.16 shall be met.

H.20 Creepage distances, clearances and distances through insulation

H.20.1 *Additional subclauses:*

H.20.1.9 Electronic controls

H.20.1.9.1 Creepage distances, clearances and distances through insulation between live parts connected electrically to the mains supply and accessible surfaces or parts shall comply with the requirements of clause 20.

H.20.1.9.2 Creepage distances, clearances and distances through insulation between live parts and parts operating at safety extra-low voltage (SELV) shall comply with the requirements of clause 20 for double or reinforced insulation unless the path is via earthed metal.

H.20.1.9.3 Creepage distances, clearances and distances through insulation shall comply:

- across protective impedance with the requirements of clause 20 for double or reinforced insulation;
- across each separate component of protective impedance with the requirements of clause 20 for supplementary insulation.

H.20.1.9.4 Creepage distances and clearances providing operational insulation shall comply with the requirements of clause 20.

H.21 Resistance to heat, fire and tracking

H.21.2.6 Ball pressure test 2

Additional dashed paragraph:

- the temperature achieved during the test of H.27.1.3, if this is higher than the temperature given in the preceding four dashed paragraphs.

H.23 Electromagnetic compatibility (EMC) requirements – emission

H.23.1 Electronic controls shall be so constructed that they do not emit excessive electric or electromagnetic disturbances in their environment.

H.23.1.1 Low frequency emission, disturbances in supply systems

Integrated and incorporated controls are not subjected to the tests of this clause, as the results of these tests are influenced by the incorporation of the control into the equipment and the use of measures to control emissions used therein. They may, however, be carried out under declared conditions if so requested by the manufacturer.

Controls in which an electronic device controls directly an external load connected to the mains power supply (the control port) shall comply with the requirements of IEC 61000-3-2 and IEC 61000-3-3. For these tests, a load and measures to control emissions, if any, shall be used as declared by the manufacturer in item 74 of table H.7.2. This requirement does not apply to controls declared and designed for pilot duty load only.

H.23.1.2 Radio frequency emission

Free-standing, independently mounted and in-line cord electronic controls using software, oscillating circuits, or switching power supplies shall comply with the requirements of CISPR 14-1 and/or CISPR 22, class B, as indicated in table H.23.

Additional details may be given in the relevant part 2.

NOTE – The relevant part 2 will indicate whether the requirements of this clause apply to integrated and incorporated electronic controls.

Table H.23 – Emission

Port	Frequency range	Limits	Basic standard	Applicability note	Remarks
Enclosure	30 – 230 MHz 230 – 1 000 MHz	30 dB(µV/m) at 10 m 37 dB (µV/m) at 10 m	CISPR 22 Class B	See note 1	The statistical evaluation in the basic standard applies
AC mains	0 – 2 kHz		IEC 61000-3-2 IEC 61000-3-3	See note 2	
	0,15 – 0,5 MHz limits decrease linearly with log. frequency	66-56 dB(µV) quasi peak 56 – 46 dB(µV) average	CISPR 22 Class B		The statistical evaluation in the basic standard applies
	0,5 – 5 MHz	56 dB(µV) quasi peak 46 dB(µV) average			
	5 – 30 MHz	60 dB(µV) quasi peak 50 dB(µV) average			
Load terminals	0,15 – 30 MHz	See basic standard Clause: discontinuous interference	CISPR 14-1		

NOTE 1 – Applicable only to controls containing processing devices, e.g. microprocessors operating at frequencies greater than 9 kHz.

NOTE 2 – Applicable only to equipment within the scope of IEC 61000-3-2 and IEC 61000-3-3. Limits for controls not currently covered by IEC 61000-3-2 and IEC 61000-3-3 are under consideration.

H.25 Normal operation

H.25.1 The output waveform of electronic controls shall be as declared.

The output waveform of the control shall be examined under all normal operating conditions and shall be either sinusoidal or as declared in table 7.2, requirement 53.

Attention is drawn to IEC 61000-3-2 and 61000-3-3, which impose restriction on mains disturbances.

H.26 Electromagnetic compatibility (EMC) requirements – immunity

H.26.1 Electronic controls shall be so constructed as to withstand the effects of mains borne perturbations, magnetic disturbances, and electromagnetic disturbances which may occur in normal use.

The tests of clause H.26 are not applicable to non-electronic controls because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic controls may be included in other clauses of the appropriate part 2.

H.26.2 *For controls with Type 2 action, compliance is checked by the tests as detailed in H.26.4 to H.26.12 inclusive*

H.26.2.1 *For controls with Type 1 action, compliance is checked by the tests of H.26.8 and H.26.9.*

For Type 1 controls, the remaining disturbances of H.26.4 to H.26.12 will not result in an inherent hazard. Inherent hazards and changes in output are assessed by the remaining tests of this standard.

H.26.2.2 *For integrated and incorporated controls with Type 1 action, compliance is checked by the tests of H.26.8 and H.26.9 if declared in table 7.2, requirement 58a.*

H.26.2.3 *For integrated and incorporated controls with Type 2 action, compliance is checked by H.26.5 and any other tests of clause H.26 which are declared in table 7.2, requirement 58a.*

The suitability of each test in H.26 to a given control may be determined by reference to the appropriate appliance standard(s) or to the manufacturer's declaration of the intended use of the control.

This determination of suitability should include an assessment:

- whether the control will be exposed to a particular type of disturbance in its application;
- whether the response of the control to the particular type of disturbance is relevant to safety in its application.

H.26.3 *A separate sample, as submitted, may be used for each test. At the option of the control manufacturer, multiple tests may be performed on a single sample.*

H.26.4 *Test of the influence of signal voltages in the power supply networks*

Requirements and tests to consider the influence on controlled outputs of signal voltages in the power supply networks are under consideration.

H.26.5 Test of the influence of voltage dips and short voltage interruptions in the power supply network

This test is carried out in accordance with IEC 61000-4-11.

H.26.5.1 Purpose of the test – Range of application

The purpose of the test is to verify the immunity of equipment against voltage dips and short voltage interruptions. Voltage dips and interruptions are caused by faults in the LV, MV, HV networks (short circuits or ground faults); in particular, dips or interruptions subsequent to fault switching with rapid reclosure with a duration of 0,5 s are to be considered.

H.26.5.2 Test voltage characteristics

The control shall be initially operated at its rated voltage and then shall be subjected to voltage dips or interruptions as detailed in H.26.5.4.

H.26.5.3 Void

H.26.5.4 Severity levels

At minimum, the following test values shall be applied.

Where intermediate durations of voltage interruption may affect either the inherent safety of the control or the output of a Type 2 control, Part 2s may indicate voltage interruptions at other points in the interval from 1 cycle to 60 s.

	ΔU	Duration
Voltage dips	30 %	0,5 s
	60 %	0,5 s
Voltage interruptions	100 %	1 cycle of supply waveform 0,5 s 60,0 s

H.26.5.5 Remarks to the test procedure

The test is performed three times.

Attention should be given to the operating modes in which the control may be particularly sensitive to voltage dips or interruptions.

In the case of three-phase equipment, it may be necessary to apply voltage dips either on the three phases simultaneously or on one or two phases only.

H.26.5.6 Ramp voltage tests

A control shall be subjected to a power increase by continuously raising the voltage from 20 % V_R to 100 % V_R at a rate of 40 % V_R per second. This test is to be repeated five times.

A control shall be subjected to a power decrease by continuously lowering the voltage from 100 % V_R to 20 % V_R at a rate of 40 % V_R per second. This test is to be repeated five times.

H.26.6 Test of influence of voltage unbalance

H.26.6.1 Purpose of the test – Range of application

This test applies only to three-phase equipment.

The purpose of the test is to investigate the influence of unbalance in a three-phase voltage system on equipment sensitive to this kind of interference, such as:

- overheating of a.c. rotating machines;
- generation of non-characteristic harmonics in electronic power converters.

The degree of unbalance is defined by the unbalance factor $T_i = \frac{U_i}{U_d} = \frac{\text{negative sequence voltage}}{\text{positive sequence voltage}}$

H.26.6.2 Test voltage characteristics

A power frequency three-phase voltage shall be applied to the control with the specified unbalance factor.

In order to obtain accurate results, this voltage should have only a very small harmonics content.

H.26.6.3 Test equipment/test generator

The test arrangement shall consist of three single-phase auto-transformers, whose outputs are regulated individually, or the like.

H.26.6.4 Severity level

The test shall be carried out with an unbalance factor of 2 % (2).

H.26.7 Test of the influence of d.c. in a.c. networks

Requirements and tests are under consideration.

H.26.8 Surge immunity test

This test is carried out in accordance with IEC 61000-4-5.

H.26.8.1 Purpose of the test – Range of application

This test is applicable to all controls. It applies to the power supply terminals and in specific cases to the control terminals.

The purpose of the test is to verify the immunity of equipment against unidirectional transients caused by different phenomena:

- switching phenomena in the power network (e.g., switching of capacitor banks);
- faults in the power network;
- lightning strikes.

The induced voltage surge can have different effects, depending on the relative impedance of the source and of the control:

- if the control has a high impedance relative to the source, the surge will produce a voltage pulse;
- if the control has a relatively low impedance, the surge will produce a current pulse.

This behaviour can be illustrated by an input circuit protected by an overvoltage suppressor: as long as the latter does not break down, the input impedance is high. When it breaks down the input impedance becomes very low. A realistic test must correspond to this behaviour and the test generator must be able to deliver a voltage pulse on a high impedance as well as a current pulse on a low impedance (hybrid generator).

H.26.8.2 Void

H.26.8.3 Void

H.26.8.4 Severity levels

Table H.26.8.4 – Severity levels

IEC 61000-4-5 installation class	Test levels (peak) kV					
	Power supply		Unbalanced operated circuits and lines		Balanced operated circuits and lines	
	Coupling mode		Coupling mode		Coupling mode	
	Line-to-line	Line-to-earth	Line-to-line	Line-to-earth	Line-to-line	Line-to-earth
2	0,5	1,0	0,5	1,0	No test	1,0
3	1,0	2,0	1,0	2,0	No test	2,0
4	2,0	4,0	2,0	4,0	No test	2,0

NOTE 1 – Tests are performed with any intended surge suppression properly installed.

NOTE 2 – In a control, a lower category may follow any higher category when appropriate transient overvoltage control means are provided.

NOTE 3 – See annex R for description of installation class and further explanatory notes.

H.26.8.5 Test procedure

The control shall be connected to an appropriate source of supply operating at the rated voltage with an impulse generator connected across the terminals.

The control is subjected to five impulses of each polarity (+, –) applied between power supply terminals and between each supply terminal and earth at intervals not less than 60 s.

H.26.9 Electrical fast transient/burst immunity test

This test is carried out in accordance with IEC 61000-4-4.

The test conditions are:

Test level:	*2*
Repetition frequency:	*5 kHz*
Generator drive:	*Internal*
Minimum number of applications:	*1 (+,–) polarity*
Operating conditions:	*as in the relevant part 2*

AC power supply and control outputs for direct connection to the supply		**DC power supply and control outputs for direct connection to the supply**	**Data lines** [1]
Direct	Between power supply lines and earth	Capacitive clamps [2]	Capacitive clamp
	Between supply lines		

[1] Applicable only to lines greater than 3 m in length, according to the manufacturer's declaration.

[2] Not applicable to lines connected to dedicated non-rechargeable power supplies.

H.26.10 Ring wave test

This test is an alternative to the fast transient burst test described in H.26.9.

In the USA, the ringwave test of clause H.26.10 is required.

H.26.10.1 Purpose of the test – Range of application

The purpose of the test is to verify the immunity of equipment to oscillatory transients ("ring waves") that appear in indoor (cable) residential and industrial LV-networks. This test is complementary to the 1,2/50 µs surge test that covers transients appearing in outdoor (overhead lines) networks. The energy involved with "ring waves" is however smaller than the energy associated with the surges; on the other hand, they may generate effects in the control due to the voltage polarity change.

H.26.10.2 Test wave characteristics

The test wave form shall consist of a pulse with a rise time of 0,5 ms, followed by an oscillation at 100 kHz with a decrement so that each peak is 60 % of the preceding peak. See figure H.26.10.1.

H.26.10.3 Test equipment/test generator

The surge generator for this immunity test is shown in figure H.26.10.2.

H.26.10.4 Severity levels

Table H.26.10.4 – Peak voltages

Rated voltage (max.)	**Category** [1][2]					
	I		**II**		**III**	
V	kV	R1	kV	R1	kV	R1
100	0,5	25	0,8	25	1,5	25
300	1,0	25	1,6	25	2,5	25
600	2,0	25	3,0	25	5,0	25

[1] kV open-circuit. See figure H.26.10.2 for R1.

[2] See annex L for categories.

In the USA, the peak voltage of the impulse wave is determined by the rated voltage and declared category of the control as given in IEC 60664-1.

H.26.10.5 Test procedure

The control shall be tested as indicated in H.26.8.5.

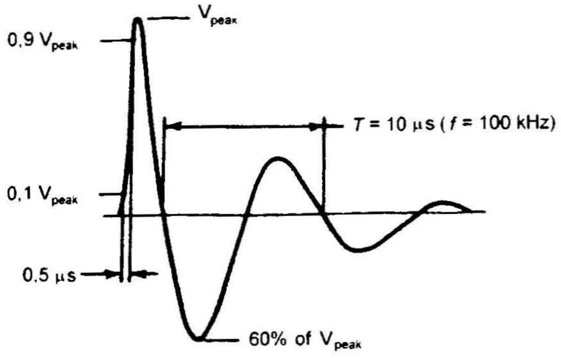


Figure H.26.10.1 – Ring wave characteristics (open-circuit voltage)

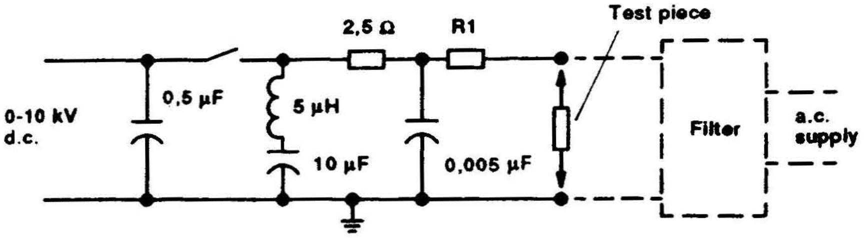


Figure H.26.10.2 – Schematic of a ring wave generator 0,5 µs/100 kHz

The value of R1 is specified in table H.26.10.4:

- R1 of 2,5 Ω will provide a 500 A peak short-circuit current
- R1 of 25 Ω will provide a 200 A short-circuit current.

H.26.11 Electrostatic discharge test

This test is carried out in accordance with IEC 61000-4-2, clause 5, severity level 3.

Contact discharges at 6 kV to accessible metal parts, or air discharges at 8 kV to accessible parts of insulating material shall apply.

H.26.12 Radio-frequency electromagnetic field immunity

H.26.12.1 Purpose of the test

The purpose of the test is to verify the immunity of equipment (single apparatus or systems) against electromagnetic fields generated by radio transmitters or any other device emitting continuous wave radiated electromagnetic energy. The immunity of equipment to the radiation of hand held transmitters (walkie-talkies) is the main concern, but other sources of electromagnetic radiation are involved, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electromagnetic sources. Also, the immunity of equipment to electromagnetic radiation received by ingoing and outgoing leads of the equipment, and which act as passive receivers to conduct electromagnetic radiation, is evaluated in this clause.

H.26.12.2 Immunity to conducted disturbances

The control shall tolerate high frequency signals on the mains supply and relevant signal terminals.

Compliance is checked with the tests of H.26.12.2.2 to H.26.12.2.3, inclusive.

H.26.12.2.1 Test levels for conducted disturbances

At minimum, the test levels in table H.26.12.2.1 shall be applied.

The tests shall only be applied to interface cables which, according to the manufacturer's specification, may be longer than 1 m.

Table H.26.12.2-1 – Test levels for conducted disturbances on mains and I/O lines

Frequency range: 150 kHz – 80 MHz	
Voltage level (e.m.f.)	
U_0 dBµV	U_0 V
130	3
NOTE – The levels in the ISM- and CB-bands are chosen to be 6 dB higher (ISM: Industrial, Scientific and Medical radio frequency equipment 13,56 ± 0,007 MHz and 40,68 ± 0,02 MHz, CB: Citizen Band: 27,125 ± 1,5 MHz)	

H.26.12.2.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-6.

Expose the control by sweeping through the complete frequency range at least once with the system in each of its relevant operating modes at a sweep rate of 1,5 × 10^3 decades per second. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the fundamental with linear interpolation between calibration points. The dwell time at each frequency shall not be less than the time necessary for the control to be exercised and be able to respond.

The sensitive frequencies or the frequencies of dominant interest may be analyzed separately.

H.26.12.3 Immunity to radiated electromagnetic fields

The control shall tolerate high frequency signals on the mains supply and relevant signal terminals. Compliance is checked with the tests of H.26.12.3.1 to H.26.12.3.2, inclusive.

H.26.12.3.1 Test level for radiated electromagnetic fields

Table 26.12.3.1 – Immunity to radiated electromagnetic fields

Frequency range: 80 MHz – 1 000 MHz
Field strength V/m
3
NOTE – The levels in the ISM- and GSM bands are chosen to be 6 dB higher. ISM: Industrial, Scientific and Medical radio frequency equipment 433,92 ± 0,87 MHz GSM: Group Special Mobile 900 MHz ± 5,0 MHz modulated by 200 Hz ± 1 % pulses of equal mark/space ratio (2,5 ms ON and 2,5 ms OFF)

H.26.12.3.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-3.

Expose each of the six sides of the control by sweeping through the whole frequency range in both the horizontal and the vertical antenna orientation in each of its relevant operating modes at a sweep rate of 1,5 × 10^3 decades per second. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the fundamental with linear interpolation between calibration points. The dwell time at each frequency shall not be less than the time necessary for the control to be exercised and be able to respond.

The sensitive frequencies or the frequencies of dominant interest may be analyzed separately.

H.26.13 Evaluation of compliance

H.26.13.1 *After the tests of H.26.2 to H.26.12 inclusive, the sample(s) shall meet the requirements of clause 8, 17.5 and clause 20.*

H.26.13.2 *In addition, the control shall meet the following:*

- *the requirements of H.17.14 or*
- *the output(s) and functions shall be as declared in table 7.2, requirements 58a and 58b.*

Compliance with the second alternative of H.26.13.2 may make the control unacceptable for some applications.

Part 2 standards may contain restrictions on the allowable effects on controlled output(s) for particular types of controls or control functions for test levels.

H.27 Abnormal operation

H.27.1 Electronic controls shall be assessed for the effects of failure or malfunction of circuit components.

Compliance is checked by the tests of H.27.1.1 to H.27.1.5 inclusive and H.27.4.

Components which fail as a result of cumulative stress are replaced if necessary.

Non-electronic components such as switches, relays and transformers, which are assessed according to clause 24 or to the relevant requirements of this standard, are not subjected to the tests of this subclause

During the tests of this subclause, for a control providing electronic disconnection (Type 1.Y or 2.Y), any failure of the device described in note 15 to table 13.2 is permitted.

H.27.1.1 Fault conditions specified in H.27.1.4 are not applied to circuits or parts of circuits where all of the following conditions are met:

- the electronic circuit is a low-power circuit as described below;
- the protection against electric shock, fire hazard, mechanical hazard or dangerous malfunction in other parts of the control does not rely on the correct functioning of the electronic circuit.

A low-power circuit is determined as follows and further explained in figure H.27.1.1.

The control is operated at rated voltage or at the upper limit of the rated voltage range and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite pole of the supply source.

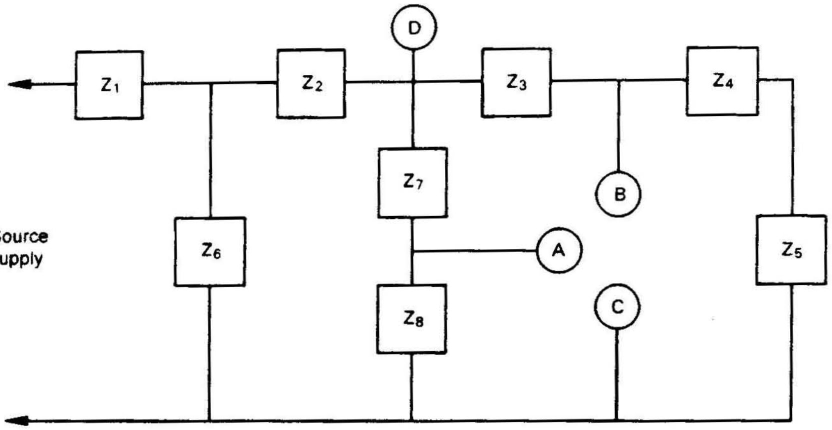
The resistance is then decreased until the power consumed by the resistor reaches a maximum. Any point nearest to the supply and at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s is called a low-power point. The part of the circuit farther from the supply source than a low-power point is considered to be a low-power circuit.

The measurements are made from only one pole of the supply source, preferably the one that gives the fewest low-power points.

When determining the low-power points, it is recommended to start with points close to the supply source

The power consumed by the variable resistor is measured by a convenient method, for example, by a wattmeter.

If an electronic circuit operates to ensure compliance with clause H.27, the relevant test is repeated with a single fault simulated, as indicated in items 1) to 5) inclusive of H.27.1.4.



D is a point farthest from the supply source where the maximum power delivered to external load exceeds 15 W .

A and B are points closest to the supply source where the maximum power delivered to external load does not exceed 15 W. These are low-power points.

Points A and B are separately short-circuited to C.

The fault conditions 1) to 5) specified in H.27.1.4 are applied individually to Z_1, Z_2, Z_3, Z_6 and Z_7, where applicable.

Figure H.27.1.1 – Example of an electronic circuit with low power points

H.27.1.2 *The control shall be operated under the following conditions:*

a) At the most unfavourable voltage in the range 0,9 to 1,1 times the rated supply voltage.

b) Loaded with the type of load, within the declared or measured parameters, producing the most onerous effect.

c) In an ambient temperature of (20 ± 5) °C, unless there are significant reasons (as for example during item b) of H.27.1.3) for conducting the test at another temperature within the manufacturer's declared range.

d) Connected to an electrical supply having a fuse rating such that the result of the test is not influenced by the operation of the fuse.

e) With any actuating member set to the most unfavourable position.

H.27.1.3 *With each fault defined in H.27.1.4 simulated or applied to one electronic device or other circuit component at a time (see H.27.1.3.1):*

- *to components complying with clause 14 of IEC 60065, the controls shall comply with items a), c), d), f) and g).*

  In the United States, if a component has received qualification approval under the IECQ programme, with appropriate conditioning periods and stress factors, the open and short circuit faults of H.27.1.4 need not be applied.

- *to components not complying with clause 14 of IEC 60065, the controls shall comply with items a) to g) inclusive.*

  a) The controls shall not emit flames, hot metal or hot plastics, and no explosion shall result.

For in-line cord controls and independently mounted controls, compliance is determined by the following test:

The enclosure with the control therein is wrapped in tissue wrapping paper. The control is operated to steady state or for one hour, whichever occurs first. There shall be no burning of the wrapping tissue paper. Inside the enclosure some parts may temporarily glow, and there may be a temporary emission of smoke or flame.

In some countries, cheesecloth is used instead of tissue wrapping paper.

Integrated and incorporated controls shall either comply with the test specified for in-line cord controls and independently mounted controls or be classified as requiring further shielding, etc., in the appliance or equipment.

b) The temperature of supplementary insulation and reinforced insulation shall not exceed 1,5 times the relevant values specified in clause 14, except in the case of thermoplastic material.

There is no specific temperature limit for supplementary insulation and reinforced insulation of thermoplastic material; the temperatures of which shall, however, be recorded for the purposes of clause 21.

c) Any change in the controlled outputs shall be as declared in table 7.2, requirement 57.

d) The control shall continue to comply with the requirements of clauses 8 and 13.

e) There shall be no deterioration of the various parts of the control that would result in failure to comply with the requirements of clause 20.

f) A fuse in the supply, external to the control under test and as described in item d) of H.27.1.2, shall not rupture unless an internal protective device also operates that is accessible only after the use of a tool.

An internal protective device is deemed not to be required if the sample still complies with the following requirements after replacement of the fuse in the supply:

- *items a), b) and d) of H.27.1.3*
- *the requirements of clause 20 for the clearances and creepage distances from active parts to the surfaces of the control that are accessible when the control is mounted as for its intended use.*

g) The output waveforms shall be as declared in table 7.2, requirement 56.

For controls declared under requirement 73 of table 7.2, simulation or application of a fault shall cause 1) or 2) to occur:

1) the control shall continue to operate normally within the declarations verified in clause 15. In this event, a second fault shall be applied and the control shall continue to operate normally within the declarations verified in clause 15 or shall cause 2) to occur;

2) the output of the control shall assume the declared conditions.

H.27.1.3.1 Guidelines for the tests of H.27.1.3

To avoid unnecessary testing, every endeavour should be made to assess all the conditions likely to result in non-compliance with the requirements of this subclause. Such an assessment shall involve an appraisal of the circuit diagram and simulation of the relevant fault conditions so as to test whether these conditions occur. For controls using software, the fault analysis of this subclause shall be related to the software fault analysis of table 7.2, requirement 68.

All conditions which result from the introduction of an electronic circuit fault as specified in H.27.1.4 are considered to be one fault.

Printed circuit conductors which show signs of deterioration during the tests are considered liable to fail.

H.27.1.4 Electronic circuit fault conditions

For the purpose of clause H.27, and subject to H.27.1.3, faults to be used are:

1) *The open-circuiting of any termination.*
2) *The short-circuiting of any two terminations of a component.*
3) *For integrated circuits and other electronic devices with more than two terminals, the open-circuiting and/or short-circuiting of any combination of terminals.*

   The number of tests implied for integrated circuits may normally make it impracticable to apply all the relevant fault conditions or to assess the likely hazards from an appraisal of the circuit diagram of the integrated circuit.

   It is therefore permissible first to analyze in detail all the possible mechanical, thermal and electrical faults which may develop either in the control itself or its output, due to the malfunction of the electronic devices or other circuit components, separately or in any combination.

   If any of these faults could result in the failure of the control to meet the requirements of this subclause, it is then necessary to establish if such a fault or faults could be caused by the failure of the integrated circuit in the manner prescribed.
4) *The effect of any full wave type of electronic device such as a triac, going into half-wave condition either controlled or uncontrolled (thyristor or diode, respectively).*
5) *The short-circuiting of any creepage distance not complying with the specified limits of clause 20.*
6) *Short-circuit of each low-power circuit by connecting the low-power point to the pole of the supply from which the measurements were made.*
7) *For A/D D/A converters, the effects of gain reduction and offset drift.*

H.27.1.5 *If the load includes a motor load (see 6.2.2 or 6.2.5), and the failure or malfunction of an electronic circuit component causes a change in the supply waveform to the controlled motor, the control shall be subjected to the following tests:*

1) *The load shall be adjusted under normal waveform conditions to six times the rated load or the locked rotor rating declared by the manufacturer.*
2) *Then the fault conditions shall be introduced.*
3) *The test is conducted under the conditions described in items a), c), d) and e) of H.27.1.2.*
4) *The control shall be evaluated according to items a) to e) inclusive of H.27.1.3, as appropriate to the component being assessed.*

H.27.4 Controls providing electronic disconnection (Type 1.Y or 2.Y) shall withstand the abnormal overvoltage conditions which may occur.

Compliance is checked by the following test:

H.27.4.1 *The control is loaded as indicated in 17.2 and subjected to 2 × V_R for 5 s, when the control is providing electronic disconnection.*

H.27.4.2 *During and after the test, the control shall continue to provide electronic disconnection as determined by the test of H.11.4.16.2.*

H.28 Guidance on the use of electronic disconnection

H.28.1 Main features of solid-state switching devices

H.28.1.1 Solid-state switching devices differ from their electro-mechanical counterparts in three respects:

a) when providing electronic disconnection, they will always allow a small current to pass through the circuit which they are controlling;

b) they are more sensitive to mains perturbations of the supply mains;

c) they are more sensitive to temperature.

H.28.1.2 The requirements and tests for electronic disconnection in this standard ensure that:

a) the current through the electronic disconnection will not exceed 5 mA or 10 % of the rated current, whichever is lower, with any load up to its maximum declared load in the circuit;

b) even under extreme conditions of mains perturbation, a control will be unaffected and will not permit the device to conduct for more than one half cycle of the supply waveform;

c) the device will have adequate endurance between the extremes of temperature in which it is designed to operate.

H.28.2 Application of solid-state switching devices

H.28.2.1 An electronic disconnection may be caused to conduct for one half cycle of the supply frequency by the application of a pulse of sufficient voltage. While full isolation from the supply is always achieved by the equivalent of full disconnection, there may be some applications when operation even for one half cycle is unacceptable.

So far as household appliances are concerned, switching on very occasionally for a maximum of one half cycle of the supply waveform can usually be disregarded. It will be of no consequence to heating appliances and to the majority of motor-operated appliances.

However, for motor-operated appliances where it is possible for the user to have contact with hazardous moving parts or to parts that become live either during normal use or user maintenance (e.g. cleaning), it will be necessary to require further safeguards or not to allow such devices. Examples of appliances for which electronic disconnection would not be appropriate are certain types of kitchen machines where access to moving parts or live parts is possible.

WARNING: For some motor-driven appliances, energization of the controlled load at mains frequency for one half cycle may cause rotation of the motor. Operation of solenoid devices may also occur.

H.28.2.2 Where the controlled load is a high impedance load such as a relay coil or solenoid, care shall be taken that the allowed current through the control when it is providing electronic disconnection is low enough to ensure disconnection of the load.

Annex J
(normative)

Requirements for controls using thermistors

This annex supplements or modifies the corresponding clauses of this standard.

J.1 Scope

J.1.1.1 *Additional paragraphs:*

This annex is applicable to controls using thermistors constructed of ceramic or polymeric semiconductor materials.

This standard applies to the inherent safety, the operating temperature values and testing of controls using thermistors either within the control or remote from it.

These thermistors may be used:

1) in a self-heating mode as self-controlled heaters and in similar applications;

2) as control elements; or

3) as sensing elements.

Part 2 standards may contain additional requirements for thermistors used as complete controls.

J.2 Definitions

J.2.15 Definitions pertaining to thermistors

J.2.15.1
thermistor
thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature (R/T) characteristic a significant non-linear change in its electrical resistance with a change in temperature

The change in temperature may occur either due to flow of current through the thermistor, as a result of a change in the ambient temperature, or by a combination of both of these occurrences.

Thermistors are not considered to be electronic devices (see annex H)

J.2.15.2
PTC thermistor
positive temperature coefficient (PTC) thermistor that exhibits an increase in resistance with increasing temperature over the useful portion of the resistance/temperature (R/T) characteristic

PTC thermistors also exhibit a decreasing resistance with applied voltage as a secondary effect.

For a PTC thermistor, the useful portion of the resistance/temperature characteristic is usually the portion in which a step-like increase in resistance occurs in a temperature increment, usually preceded by a gradual change in resistance at lower temperatures, and a similar gradual change at temperatures above the step-like increase. The resistance/temperature characteristic of some PTC thermistors may take on a negative slope after a slight gradual increase following the step-like increase.

J.2.15.3
NTC thermistor
negative temperature coefficient (NTC) thermistor that exhibits a decrease in resistance with increasing temperature over the useful portion of the resistance/temperature characteristic

J.2.15.4
thermistor control element
PTC or NTC thermistor which directly controls a load by being connected in series with it

J.2.15.5
self-controlled heater
PTC thermistor which has no additional temperature limiter and which is used as a heater element because of its self-heating effect

Normally a self-controlled heater will provide a Type 2 action.

J.2.15.6
thermistor sensing element
PTC or NTC thermistor used as a sensor and which does not carry load current

J.4 General notes on tests

J.4.3.5 According to purpose

Additional subclause:

J.4.3.5.4 Type 1 controls using thermistors as temperature sensing devices where self-heating is negligible are not subjected to the tests for thermistors.

J.6 Classification

J.6.4 According to features of automatic action

J.6.4.3.3 *Additional paragraph:*

For the purpose of this standard, a PTC thermistor control or sensing element that is in the switched mode (high resistance) or an NTC thermistor in the unswitched mode (high resistance), are considered to provide the equivalent of micro-interruption.

J.6.15 According to construction

Additional subclause:

J.6.15.5 Control using NTC or PTC thermistors

Additional subclauses:

J.6.17 According to use of the thermistor

J.6.17.1 – thermistor control element;

J.6.17.2 – self-controlled heater;

J.6.17.3 – thermistor sensing element.

J.7 Information

Table 7.2

	Information	Clause or subclause	Method
61	According to the use of a thermistor	J.6.17	X
62	R/T characteristics [10]	J.15.7 J.17.17.1 J.12.2.1	X
63	R/T characteristics drift [11]	J.17.18.2	X
64	Number of cycles	J.17.18.2	X
65	Method of R/T measurement	J.15.7 J.17.18.1	X

Additional notes to table 7.2:

[10] The R/T characteristics shall be expressed in the form of a curve, a table or various operating points and shall include the declared deviation.

[11] Additional declarations may be made at intermediate numbers of cycles for the test of J.17.18.2.

J.12 Moisture and dust resistance

J.12.2 Protection against humid conditions

J.12.2.1 *Addition:*

For Type 2 controls using thermistors, R/T measurements are performed before and after the test and the R/T characteristic and its drift shall be within the declared limits.

Measurements should be performed soon after the test so as to avoid any significant change due to the environment.

J.13 Electric strength and insulation resistance

J.13.2 Electric strength

Modification to note 5) of table 13.2:

Add the word "thermistors," after "electronic parts".

J.15 Manufacturing deviation and drift

Additional subclause:

J.15.7 The resistance/temperature (R/T) characteristic shall be determined as indicated in J.12.2.1 and J.17.17 using the method declared by the manufacturer as specified in table 7.2, requirement 65.

J.17 Endurance

Additional subclauses:

J.17.17 The sequence of tests is as follows:

a) for Type 1 controls using thermistors

- *thermal runaway (PTC), J.17.18.5;*
- *overcurrent test (NTC), J.17.18.6.*

b) for Type 2 controls using thermistors

1) R/T measurements before and after each of the following:
   - *extended cycling, J.17.18.2;*
   - *thermal conditioning, J.17.18.3;*
   - *cold environmental electrical cycling, J.17.18.4.*

2) the tests for Type 1 controls using thermistors.

J.17.17.1 After the tests of J.17.18.1 to J.17.18.4 inclusive, the performance of the control shall not be adversely affected and it shall function as intended and declared.

Failure of other parts of the control during the tests of J.17.18.2 and J.17.18.3 is to be ignored.

Additionally, for Type 2 controls using thermistors, the R/T characteristic or range of characteristics shall be determined as indicated in item b) of J.17.17 and shall be as declared in requirement 63 of table 7.2.

J.17.17.2 After the tests of J.17.18.5 and J.17.18.6 the control shall continue to comply with the requirements of clauses 8 and 13. During and after the tests, there shall be no emission of flames or expulsion of particles.

J.17.18 Test conditions

Unless otherwise indicated, the control is not powered or energized during the tests of J.17.18. The complete sequence of tests is conducted on three samples, except that the tests of J.17.18.3.1 and J.17.18.3.2 may be conducted simultaneously on separate samples.

The tests of J.17.18.2 to J.17.18.4 inclusive may be conducted on the thermistor alone, using the mounting, method of connection and housing material as provided in the control.

J.17.18.1 Method of R/T measurement

The method of measurement used (see table 7.2 requirement 65) should include considerations such as self-heating, thermal dissipation and voltage effect, which may produce an erroneous R/T curve

J.17.18.2 Extended cycling

The thermistor is subjected to the number of cycles declared by the manufacturer as specified in table 7.2 requirement 64 over the portion of the R/T curve used in the application.

Typically, this portion includes the lower temperature gradual change in resistance and the temperature increment in which the step-like change in resistance takes place.

Self-controlled heaters and thermistor control elements shall be cycled electrically under maximum rated voltage and load conditions.

Thermistor sensing elements shall be cycled thermally under maximum rated electrical conditions.

J.17.18.3 Thermal conditioning

The temperatures for the tests of J.17.18.3.1 and J.17.18.3.2 are taken from the R/T declaration in table 7.2 requirement 62.

J.17.18.3.1 Unswitched mode

The control is conditioned without energization in a circulating air oven for a period of 1 000 h at a temperature just below the temperature increment in which a step-like change in resistance occurs.

This test is not applicable to controls using thermistors as self-controlled heaters.

J.17.18.3.2 Switched mode

The control is conditioned without energization in a circulating air oven for a period of 1 000 h at a temperature 30 K above the temperature increment in which a step-like change in resistance occurs.

J.17.18.4 Cold environmental electrical cycling

The control is placed in a chamber at 0 °C or T_{min}, whichever is the lower, and allowed to attain this temperature. The thermistor is then cycled at the declared maximum rated electrical conditions over the significant portion of the R/T curve for 1 000 cycles.

J.17.18.5 Thermal runaway

The thermistors are to be energized and operated under maximum rated conditions until thermally stabilized. The voltage is then to be gradually increased until breakdown occurs, or two times the working voltage of the thermistor is reached, at which time the test may be terminated.

Increasing the voltage in steps of 0,1 times the working voltage of the thermistor every 2 min constitutes an appropriate rate of rise.

J.17.18.6 Overcurrent test

This test is applicable to controls using NTC thermistors as control elements.

The thermistors are to be operated at the declared maximum rated electrical conditions until thermally stabilized. The current through the element is then to be gradually increased until 1,5 times the maximum working current of the thermistor is reached.

Increasing the current in steps of 0,1 times the maximum working current of the thermistor every 4 min constitutes an appropriate rate of rise.

J.20 Void

J.24 Components

J.24.2.1 *Add the following:*

This subclause is applicable to thermistors previously tested under IEC 60738-1, IEC 60738-1-1 or IEC 60539.

Annex K
(informative)

Nominal voltages of supply systems for different modes of overvoltage control

Table K.1 – Inherent control or equivalent protective control

Voltage line-to-neutral from nominal voltages a.c. or d.c.[1] V	Nominal voltages presently used in the world				Rated impulse voltage for equipment[1] V			
	Three-phase four-wire systems with earthed neutral V	Three-phase three-wire systems unearthed V	Single-phase two-wire systems a.c. or d.c. V	Single-phase three-wire systems a.c. or d.c. V	Overvoltage category			
					I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30 / 60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	120 / 208* 127 / 220	115; 120; 127	110; 120	110 / 220 120 / 240**	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277; 347; 380; 400; 415; 440; 480	220	220 / 440	1 500	2 500	4 000	6 000
600	347 / 600; 380 / 660 ; 400 / 690 ; 417 / 720; 480 / 830	500; 577; 600	480	480 / 960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

1) These columns are taken from table 1 of IEC 60664-1 in which the rated impulse voltage values are specified. See 2.1.1.2 of IEC 60664-1 for the definitions of protective control and inherent control.

* Practice in the USA and Canada.

** For 120/240 V in Japan, the preferred series of rated impulse voltages of 1 500 V, 2 500 V, 4 000 V and 6 000 V are used corresponding to overvoltage categories I, II, III and IV.

Table K.2 – Cases where protective control is necessary and control is provided by surge arresters having a ratio of clamping voltage to rated voltage not smaller than that specified by IEC 60099-1

Voltage line-to-neutral from nominal voltages a.c. or d.c. 1)	Nominal voltages presently used in the world				Rated impulse voltage for equipment 1) V			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems a.c. or d.c.	Single-phase three-wire systems a.c. or d.c.	Overvoltage category			
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30/60	330	500	800	1 500
100	66/115	66	60		500	800	1 500	2 500
150	120/208* 127/220	115; 120; 127	110; 120	110/220 120/240	800	1 500	2 500	4 000
300	220/380; 230/400; 240/415; 260/440; 277/480	220; 230; 240; 260; 277	220	220/440	1 500	2 500	4 000	6 000
600	347/600; 380/660; 400/690: 417/720; 480/830	347; 380; 400; 415; 440; 480; 500; 577; 600	480	480/960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

1) These columns are taken from table 1 of IEC 60664-1 in which the rated impulse voltage values are specified. See 2.1.1.2 of IEC 60664-1 for the definitions of protective control and inherent control.

* Practice in the USA and Canada.

Annex L
(normative)

Overvoltage categories

Overvoltage category is a numeral characterizing a transient overvoltage condition.

The following information on overvoltage categories is based on IEC 60664-1.

NOTE – Part 2s may specify a different overvoltage category for particular applications.

Equipment of overvoltage category IV is for use at the origin of the installation.

NOTE – Examples of such equipment are electricity meters and primary overcurrent protection equipment.

Equipment of overvoltage category III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements.

NOTE – This category normally applies to controls intended for connection to fixed wiring or for incorporation into equipment intended for permanent connection to fixed wiring, unless the control or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

Equipment of overvoltage category II is energy consuming equipment to be supplied from the fixed installation.

NOTE – This category normally applies to controls not provided with terminals for fixed wiring, or connected after a socket-outlet, or for incorporation into equipment connected after a socket-outlet. Controls intended for permanent connection to fixed wiring may also come into this category, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or clearances between conductive parts are incorporated in the control or equipment. Where the contacts of a control are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this may provide adequate suppression; for example, controls for household appliances satisfying the above descriptions.

If such equipment is subjected to special requirements with regard to reliability and availability, overvoltage category III applies.

Equipment of overvoltage category I is equipment for connection to circuits in which measures are taken to limit transient overvoltages to an appropriately low level.

NOTE – This category normally applies to controls connected after category II equipment and which, for example, includes electronic logic systems, isolated limited secondary circuits, safety extra-low voltage circuits, and circuits on the secondary side of a transformer.

Annex M
(informative)

Typical usage

Table M.1 – Typical usage

Control situation	Overvoltage category			
	I	II	III	IV
Special				
Energy limited SELV	X			
Transient limited supply	X	X	X	X
Energy consuming utilization equipment				
Integrated and incorporated controls in household appliances		X		
Independently mounted controls for fixed-wiring to energy consuming loads		X	X	
Other household and similar applications				
Controls which are not integrated, incorporated, or for fixed-wiring to energy consuming loads			X	
Controls mounted at the origin of installation (i.e. service entrance equipment, electricity meters and primary overcurrent equipment)				X
Controls covered by special part 2 considerations	X	X	X	X

Annex N
(normative)

Pollution degrees

N.1 Pollution

The micro-environment determines the effects of pollution on the insulation. The macro-environment, however, has to be taken into account when considering the micro-environment.

Means may be provided to reduce pollution at the insulation under consideration by the effective use of coatings, enclosures, encapsulation or hermetic sealing. Such means to reduce pollution may not be effective when the equipment is subject to condensation or if, in normal operation, it generates pollutants itself.

Small clearances can be bridged completely by solid particles, dust and water and therefore minimum clearances are specified where pollution may be present in the micro-environment.

NOTE 1 – Pollution will become conductive in the presence of humidity. Pollution caused by contaminated water, soot, metal or carbon dust is inherently conductive.

NOTE 2 – Conductive pollution by ionized gases and metallic depositions occurs only in specific instances, for example in arc chambers of switchgear or controlgear and is not covered by this standard.

N.2 Degrees of pollution in the micro-environment

For the purpose of evaluating creepage distances and clearances, the following four degrees of pollution in the micro-environment are established:

Pollution degree 1

No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

NOTE – Special considerations (e.g. coating evaluated to annex P or annex Q, sealed enclosure) are necessary to establish pollution degree 1.

Pollution degree 2

Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE – Pollution degree 2 is representative of normal household air circulation.

Pollution degree 3

Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

Pollution degree 4

The pollution generates persistent conductivity caused by conductive dust or by rain or snow.

Annex P
(normative)

Printed circuit board coating performance test

P.1 A coating intended to be used on a printed circuit board that has creepages in accordance with clause 20, pollution degree 1, shall comply with the requirements of this annex.

P.2 A printed circuit board assembly that is used with a coating, including inks, solder resists and assembled components, is to be acceptable for its application in terms of temperature, solder conditions, conductor size and adhesion to the base material as determined by the requirements of IEC 60249 and IEC 60326.

P.3 Electric strength of coating – A coating shall withstand the electric strength test of 13.2 for operational insulation at a test voltage determined from table 13.2, based on the maximum working voltage supplied to the board assembly, after the conditioning of clauses P.3.3 and P.3.4.

P.3.1 Ten test samples shall be prepared with the minimum applicable creepage distances and the minimum coating thickness using the pattern shown in figure P.1. The samples are to be prepared by normal production means using the primer or cleaner employed prior to applying the coating to the board. Wiring suitable to the voltages and temperatures involved is to be attached.

P.3.2 Ageing test – Five samples of the coated board as described in P.3.1 shall be subjected to a temperature of 130 °C ± 2 °C for 1 000 h.

P.3.3 Humidity conditioning – The five samples of the coated board which were subjected to the ageing test of P.3.2 are to be conditioned for 48 h in a test chamber at a temperature of (35 ± 1) °C and (90 ± 5) % relative humidity. Immediately following removal from the test chamber, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

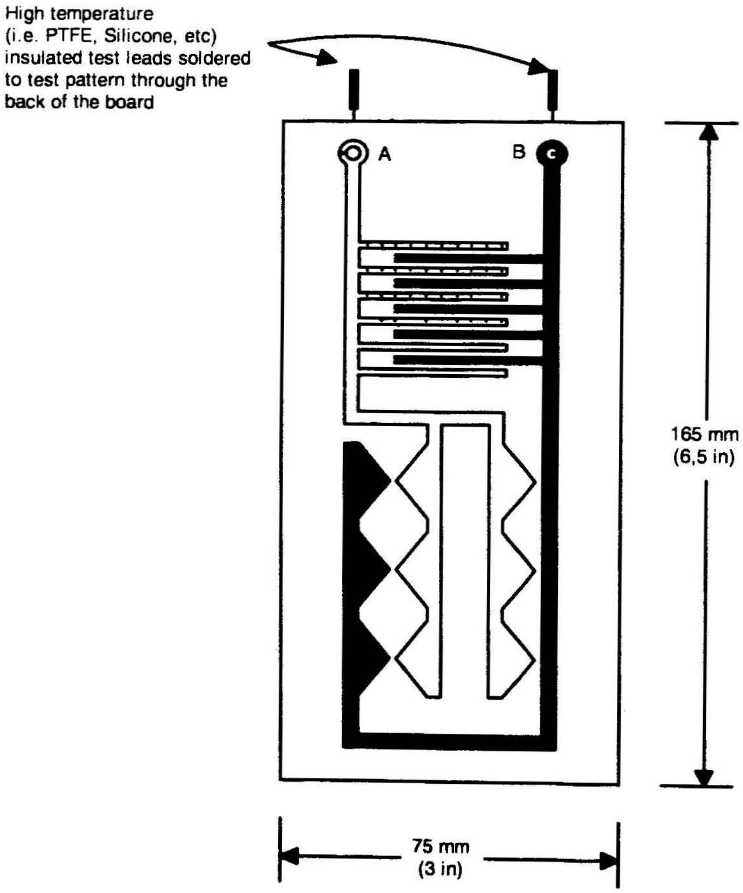
P.3.4 Environmental cycle conditioning – Five of the samples of the coated board described in P.3.1 are to be subjected to three complete cycles of environmental conditioning as described in table P.1. Immediately following the conditioning, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

P.3.5 After conditioning, the samples of the coated board as described in P.3.1 are to be provided with tight-fitting aluminum foil (representing an electrically conductive deposit along the surface of the coating) that covers the test pattern except for the insulated test lead wire and solder points.

P.3.6 The voltage stress is to be applied according to P.3 to each conditioned sample between leads A, B, and C individually and the common lead (see figure P.1). No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

Table P.1 – Environmental cycling conditions

For indoor applications	For outdoor applications
24 h at T_{max}; followed by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (0 ± 2) °C	A minimum of 24 h immersed at (25 ± 2) °C; followed immediately by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (–35 ± 2) °C


High temperature
(i.e. PTFE, Silicone, etc)
insulated test leads soldered
to test pattern through the
back of the board
A
B
C
165 mm
(6,5 in)
75 mm
(3 in)

NOTE – The smallest distance between tracks (point-to-point, point-to-line and line-to-line), shall represent the minimum distance to be permitted on production assemblies.

Figure P.1 – Test sample

Annex Q
(normative)

Printed circuit board coating performance test

Q.1 A printed wiring board conforming with all of the requirements for type A coating as specified in IEC 60664-3 shall comply with the minimum creepage requirements of clause 20 of this standard, pollution degree 1.

Q.2 A printed wiring board conforming with all of the requirements for type B coating as specified in IEC 60664-3 shall comply with the minimum requirements for solid insulation as specified in 20.3 of this standard. No creepage or clearance dimensions apply to conductor dimensions for type B coating.

Q.3 Actual printed boards representative of production samples or standard test boards according to figures Q.1 and Q.2 may be used for the tests. Thirteen samples are required for type A tests, seventeen samples for type B tests.

Q.4 *Compliance with the requirements for type A or type B coating shall be checked by the tests of IEC 60664-3, clause 6.*

Q.5 For the tests of IEC 60664-3, clause 6, the following test levels or conditions apply:

IEC 60664-3, subclause		Test level of this standard
6.6.1	Cold storage	−25 °C
6.6.3	Rapid change of temperature	Degree of severity 2 (−25 °C to +125 °C)
6.7	Electromigration	Not applicable unless specified in part 2
6.8.6	Partial discharge	Not applicable unless specified in part 2

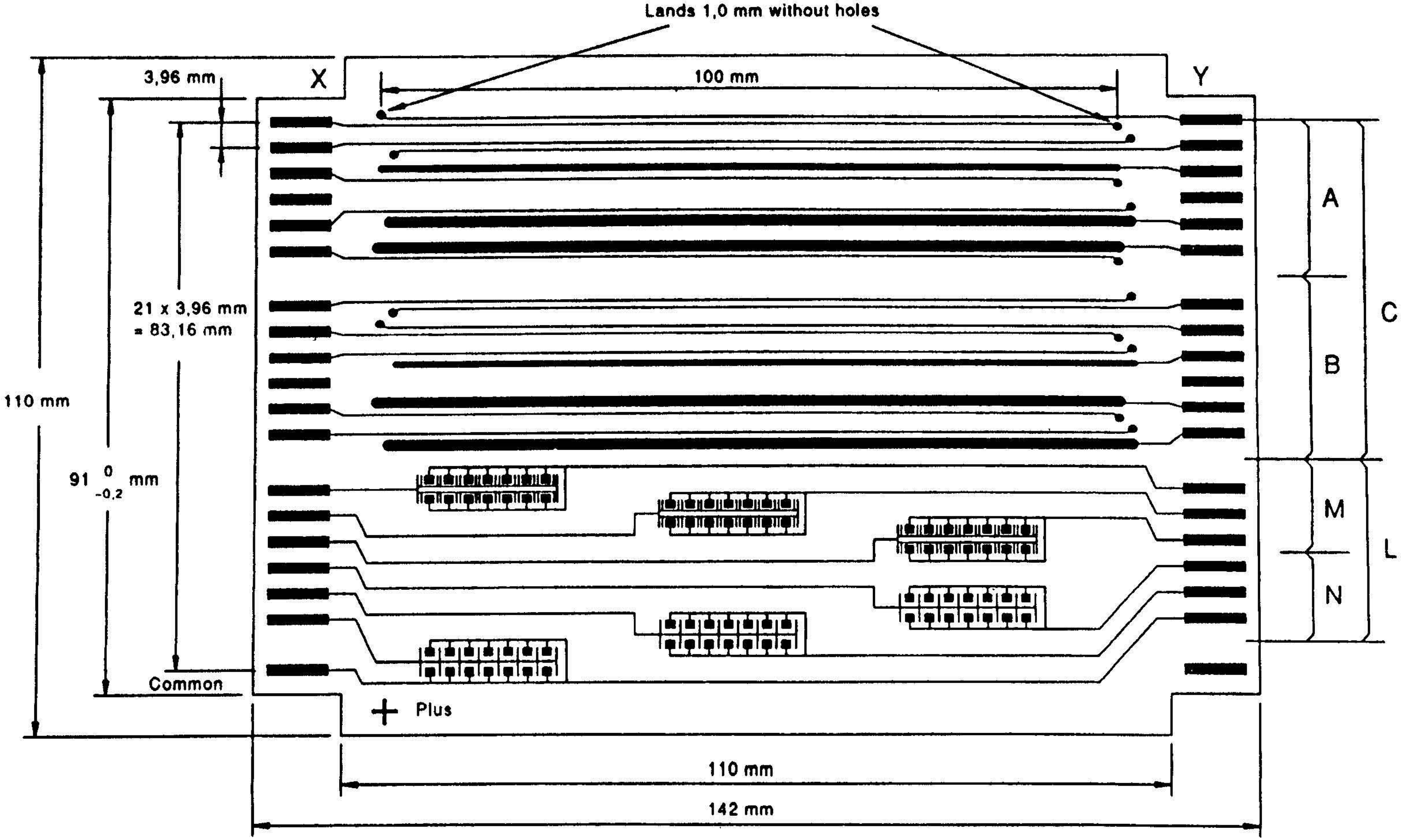


Figure Q.1 – Test sample

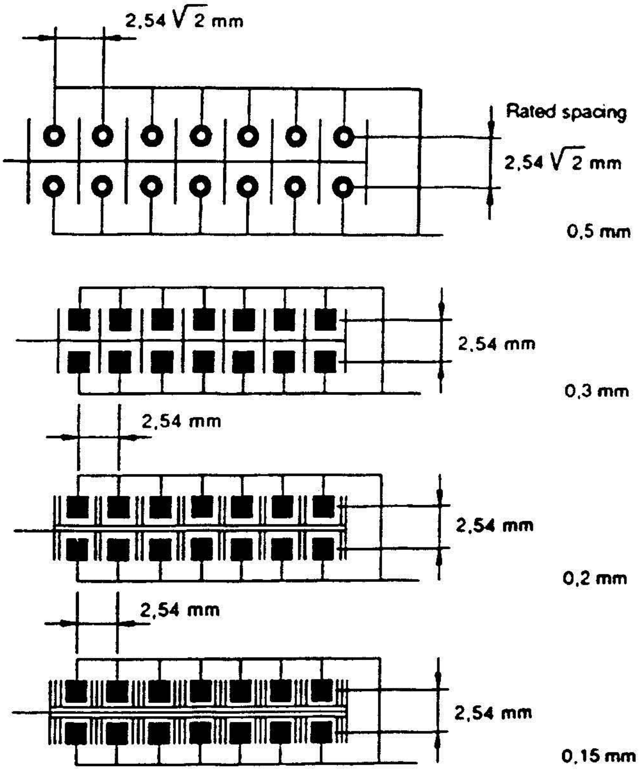


Figure Q.2 – Examples of land configurations
(see also figure Q.1)

Annex R
(informative)

Explanatory notes for surge immunity test

R.1 Different source impedances

The selection of the source impedance of the generator depends on:

- the kind of cable/conductor/line (power supply a.c., power supply d.c., interconnection, etc.);
- the length of the cables/lines;
- indoor/outdoor conditions;
- application of the test voltage (line-to-line or line-to-earth).

The impedance of 2 Ω represents the source impedance of the low voltage power supply network.

The generator with its effective output impedance of 2 Ω is used.

The impedance of 12 Ω (10 Ω + 2 Ω) represents the source impedance of the low voltage power supply network and earth.

The generator with an additional resistor of 10 Ω in series is used.

The impedance of 42 Ω (40 Ω + 2 Ω) represents the source impedance between all other lines and earth.

The generator with an additional resistor of 40 Ω in series is used.

In the USA, standards for a.c. lines require the test according to figures H.26.8.5 and H.26.8.7 with a 2 Ω impedance. This is a more severe test. The general requirement is 10 Ω.

R.2 Application of the tests

Two different kinds of tests are to be distinguished: at equipment level and at system level.

R.2.1 Equipment level immunity

The test shall be carried out in the laboratory on a single EUT. The immunity of the EUT thus tested is referred to as equipment level immunity.

The test voltage shall not exceed the specified capability of the insulation to withstand high voltage stress.

R.2.2 System level immunity

The test carried out in the laboratory refers to the EUT. The equipment level immunity does not assure the immunity of a system in all cases. For that reason a test on system level is advised which simulates the real installation. The simulated installation comprises protection devices (arrestors, varistors, shielded lines, etc.) and the real length and type of the interconnection lines.

This test is aimed at simulating as closely as possible the installation conditions in which the EUT or EUTs are intended to function later on.

In the case of the immunity under real installation conditions, higher test levels can be applied, but the energy involved will be limited by the protective devices according to their current limiting characteristics.

The test is also intended to show that secondary effects produced by the protective devices (change of waveform, mode, amplitude of voltages or currents) do not cause unacceptable effects on the EUT.

R.3 Installation classification

Class 2: Electrical environment where cables are well separated, even on short runs.

The installation is earthed via a separate earth line to the earthing system of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning. The power supply to the electronic equipment is separated from other circuits, mostly by a special transformer for the power supply. Non-protected circuits are in the installation, but well separated and in restricted numbers.

This class applies to category I equipment. Category I normally applies to controls connected after category II equipment and which, for example, includes extra-low voltage electronic logic systems, isolated limited secondary circuits, safety extra-low voltage circuits, and circuits on the secondary side of a transformer.

Surge may not exceed 1 kV.

Class 3: Electrical environment where power and signal cables run in parallel.

The installation is earthed to the common earthing system of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning.

Current due to earth faults, switching operations and lightning in the power installation may generate interference voltages with relatively high amplitudes in the earthing system. Protected electronic equipment and less sensitive electric equipment are connected to the same power supply network. The interconnection cables can be partly routed as outdoor cables but close to the earthing network. Unsuppressed inductive loads are in the installation and usually there is no separation of the different field cables.

This class applies to category III or category II equipment.

Category III normally applies to controls intended for connection to fixed wiring or for incorporation into equipment intended for permanent connection to fixed wiring, unless the control or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

Category II normally applies to controls connected after a socket-outlet or for incorporation into equipment connected after a socket-outlet. Controls intended for permanent connection to fixed wiring may also come into this category, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or clearances between conductive parts, are incorporated in the control or equipment. Where the contacts of a control are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this may provide adequate suppression. For example, controls for household appliances satisfying the above descriptions.

Surge may not exceed 2 kV.

Class 4: Electrical environment where the interconnections are running as outdoor cables along with power cables, and cables are used for both electronic and electric circuits.

The installation is connected to the earthing system of the power installation which can be subjected to interference voltages generated by the installation itself or by lightning. Currents in the kiloamperes range due to earth faults, switching operations and lightning in the power supply installation may generate interference voltages with relatively high amplitudes in the earthing system. The power supply network can be the same for both the electronic and the electric equipment. The interconnection cables may run as outdoor cables even to the high voltage equipment.

A special case of this environment is when the electronic equipment is connected to the telecommunication network within a densely populated area. There is no systematically constructed earthing network outside the electronic equipment and the earthing system consists of pipes, cables, etc. only.

Surge may not exceed 4 kV.

Examples of the installation of electronic equipment in different areas are given in figures R.1, R.2, and R.3.

R.3.1 Equipment level immunity of ports connected to the power supply network

The minimum immunity level for connection to public supply network is:

Line-to-line coupling:	0,5 kV
Line-to-earth coupling:	1 kV

R.3.2 Equipment level immunity of ports connected to interconnection lines

Surge tests on interconnection circuits are only required for external connections (outside the cabinet/housing). If it is possible to test at the system level (EUT with interconnection cables connected) it is not necessary to test at the equipment level (e.g. ports of the process-control/signal inputs/outputs) especially in cases where the shield of the interconnection cable is part of protection measures. If the installation of the plant is carried out by someone other than the manufacturers of the equipment, the admissible voltage for the inputs/outputs (especially for the process-control interface) of the EUT should be specified.

The manufacturer should test his equipment on the basis of the specified test levels to confirm the equipment level immunity, e.g. with secondary protection at the ports of the EUT for a test level of 0,5 kV. The user of the plant or those responsible for the installation should then apply measures (e.g. shielding, bonding, earthing, protection) necessary to ensure that the interface voltage caused by, for example, lightning strokes does not exceed the chosen immunity level.

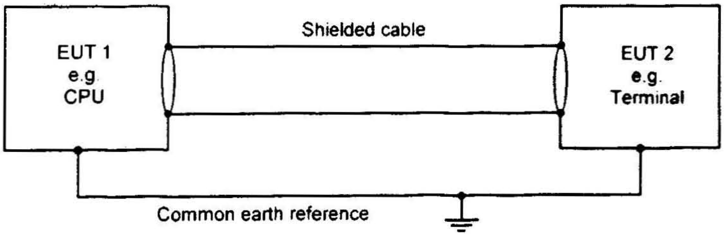


Figure R.1 – Example of surge protection by shielding in buildings with common earth reference systems

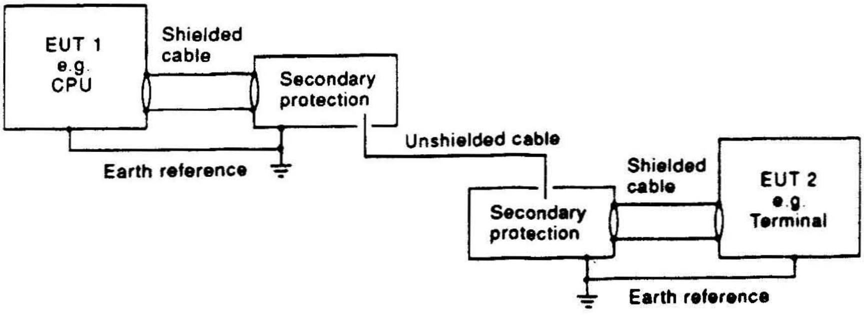


Figure R.2 – Example of secondary surge protection in buildings with separate common earth reference systems

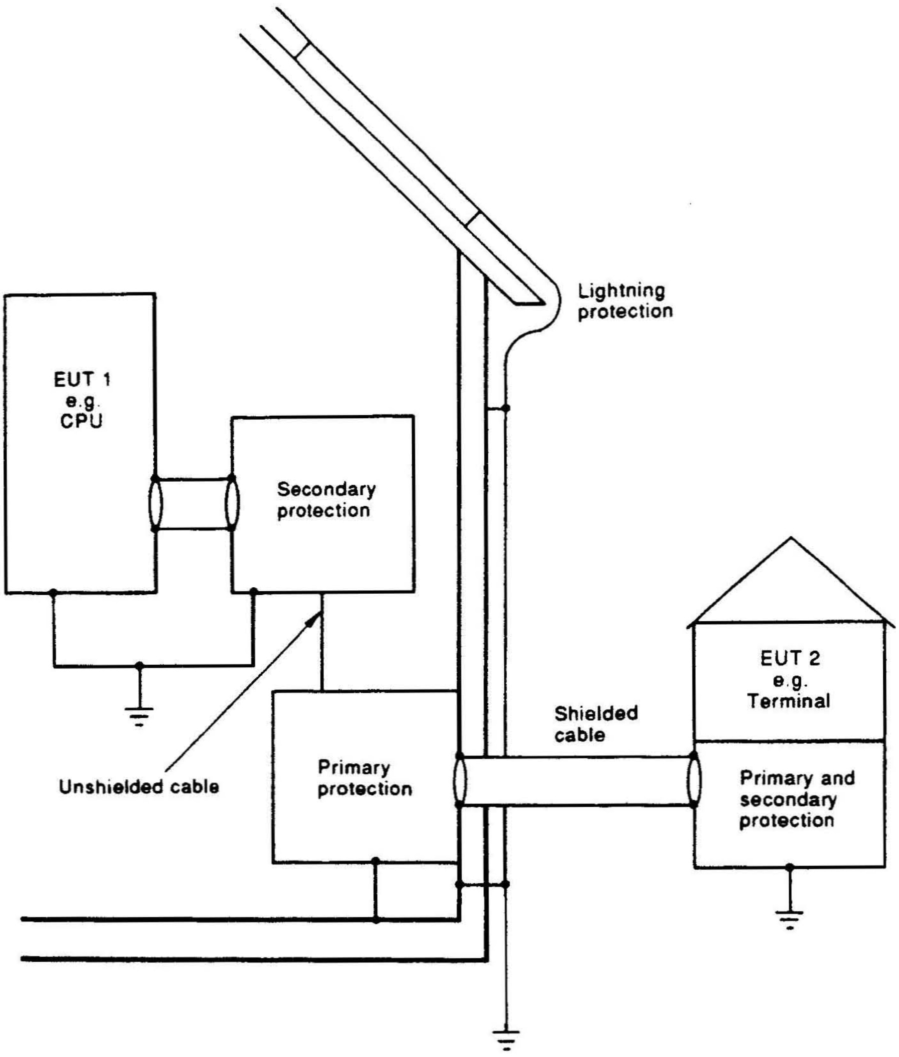
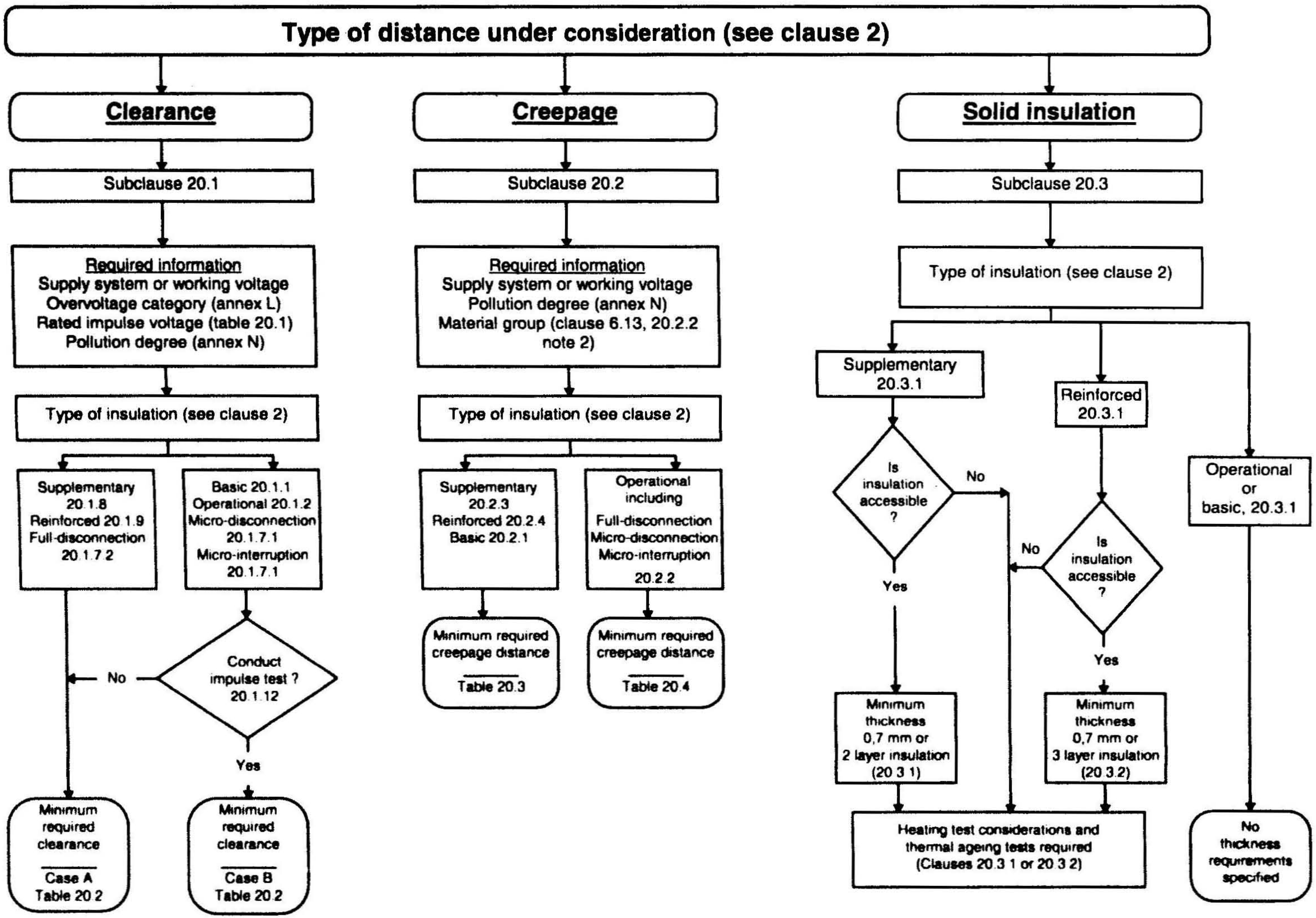


Figure R.3 – Example of primary and secondary surge protection of indoor/outdoor equipment

Annex S
(informative)
Guidance for applying clause 20


Type of distance under consideration (see clause 2)
Clearance
Creepage
Solid insulation
Subclause 20.1
Subclause 20.2
Subclause 20.3
Required information
Supply system or working voltage
Overvoltage category (annex L)
Rated impulse voltage (table 20.1)
Pollution degree (annex N)
Required information
Supply system or working voltage
Pollution degree (annex N)
Material group (clause 6.13, 20.2.2 note 2)
Type of insulation (see clause 2)
Type of insulation (see clause 2)
Type of insulation (see clause 2)
Supplementary 20.1.8
Reinforced 20.1.9
Full-disconnection 20.1.7.2
Basic 20.1.1
Operational 20.1.2
Micro-disconnection 20.1.7.1
Micro-interruption 20.1.7.1
Conduct impulse test ? 20.1.12
No
Yes
Minimum required clearance
Case A
Table 20.2
Minimum required clearance
Case B
Table 20.2
Supplementary 20.2.3
Reinforced 20.2.4
Basic 20.2.1
Operational including
Full-disconnection
Micro-disconnection
Micro-interruption
20.2.2
Minimum required creepage distance
Table 20.3
Minimum required creepage distance
Table 20.4
Supplementary 20.3.1
Reinforced 20.3.1
Operational or basic, 20.3.1
Is insulation accessible ?
No
Yes
Is insulation accessible ?
No
Yes
Minimum thickness 0,7 mm or 2 layer insulation (20.3.1)
Minimum thickness 0,7 mm or 3 layer insulation (20.3.2)
Heating test considerations and thermal ageing tests required (Clauses 20.3.1 or 20.3.2)
No thickness requirements specified

Example A – Using annex S guidance for applying clause 20

Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Through air	Follow clearance path of flow chart
What is the system supply voltage, or for operational insulation, the working voltage?	230 V/400 V, 3-phase, 4 wire	Record as a)
What is the overvoltage category? (refer to annex L)	See category II	Record as b)
What is the rated impulse voltage?	Determine from table 20.1 using a) and b)	Record as c)
What is the pollution degree? (refer to annex N)	Pollution degree 2	Record as d)
What is the type of insulation? (refer to definitions, etc.)	Reinforced insulation	Refer to 20.1.5. For reinforced insulation use case A and next highest impulse voltage step from table 20.2. Record as e).
What is the limit for this distance?	Refer to table 20.2	Determine the limit using d) and e)
	The limit is 3 mm	

Example B – Using annex S guidance for applying clause 20

Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Across a surface	Follow creepage distance path
What is the system supply voltage, or for operational insulation, the working voltage?	230 V	Record as a)
What is the pollution degree? (refer to annex N)	Pollution degree 2	Record as b)
What is the material group? (refer to 20.2.2, note 2)	IIIb)	Record as c)
What is the type of insulation? (refer to definitions, etc.)	Operational insulation	Refer to 20.2.2.
What is the limit for this distance?	Refer to table 20.4	Determine the limit using a), b) and c)
	The limit is 2,5 mm	

KEY-WORD INDEX
(informative)

Definition	Clause/subclause number
	– A –
Abraham test	H.2.19.1, Table H.11.12.7 items 1.1 & 4.2
Accessible conductive part	2.2.2, 2.7.4, 2.7.10, 2.7.11, 2.7.12
Accessible insulating surfaces	2.7.10, 2.7.11, 2.7.12, 4.3.3.2
Accessible part	2.7.8, 2.7.9, 2.8.9, 8.2.3, Table 13.2 note 12, H.8.1.10, H.8.1.10.1, H.11.2.5, H.20.1.9.1, H.26.11
Accessible surface	2.7.8, 2.12.2, 9.2, 13.3.1, Table 14.11, 18.2.4, 20.1, 20.1.6.1, 20.1.9, 20.2.1, 20.2.2, 21.2.7, H.20.1.9.1
Activating quantity	2.2.4, 2.3.5, 2.3.10, 2.3.11, 2.4.3, 2.8.1, 2.8.7, 4.3.4.2, Table 7.2 items 36, 37 & 38, Table 7.2 notes 3 & 4, 11.3.2, 14.4.3.3, 14.7, 15.5.5, 17.6.1, 17.6.2, 17.7.3, 17.7.5, 17.9.3, 17.10.3, 17.11.4, 17.12.4, 17.13.4, H.2.4.6
Actuating means	2.8.4, 4.1.6, 8.2, 8.2.2, 8.2.3, 11.6.2, Table 13.2, 16.1.1, 16.2.3, 18.9, 18.9.2
Actuating member	2.3.7, 2.3.8, 2.3.9, 2.3.15, 2.5.11, 2.8.3, 2.8.4, 2.8.5, 2.8.7, 4.1.3, 4.1.6, 8.2, 8.2.1, 8.2.2, 8.2.3, 8.3.2.2, 9.1.1, 9.1.2, 11.3.6, 11.3.8, 11.11.1.2, 11.11.3, 11.11.3.1, 11.11.3.2, 11.11.3.3, 14.4.2, 14.7.3, Table 14.1, 16.1.1, 16.2.3, 17.4.1, 17.4.2, 17.4.3, 17.4.4, 17.7.7, 17.8.4, 17.14, 18.1.2, 18.2.4, 18.2.6, 18.9, 18.9.1, 18.9.2, 18.9.3, H.227.1.2
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Adjustable set point	2.3.23
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	– B –
Basic insulation	2.4.2, 2.7.2, 2.7.3, 2.7.4, 2.7.5, 2.7.10, 2.7.11, 2.11.12, 2.11.13, 8.1.2, 8.1.9.4, 8.1.9.5, 11.2.1, Table 13.1, Table 13.2, 20.1.1, 20.1.8, 20.1.9, 20.1.10, 20.2.1, Table 20.3, 20.2.3, 20.2.4, H.7
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	– C –
Checkerboard memory test	H.2.19.2.1, H.2.19.6.1
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Class 0I control	2.7.3, Table 13.2 note 9
Class I control	2.7.4, 4.3.3.1, 4.3.3.2, 11.1.3.1, 11.9.4
Class II control	2.7.5, 2.7.5.1, 4.3.3.1, 4.3.3.2, 4.3.3.3, Table 7.2 item 25, 8.1.2, 8.1.4, 8.1.5, 10.1.12, 11.2.2, 11.7.2.2, 12.3.3, 13.3.4, 18.1.2
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Definition	Clause/subclause number
Clearance	1.5, 2.12, 2.12.1, Table 7.2 note 5, 10.1.4.2, 10.1.4.3, 10.1.5, 10.2.3, 10.2.4.4, 11.2.2, 11.2.3.11, 11.3.2, 11.4.4, 11.5, 11.7.2.14, 11.9.1.1, 12.1.2, Table 13.2, 14.7.4, 18.1.5, 20, 20.1, Table 20.2, 20.1.1, 20.1.2, 20.1.6, 20.1.6.1, 20.1.7, 20.1.7.1, 20.1.8, 20.1.9, 20.1.10, 20.1.11, 20.2.2, Table 20.3, Table 20.4, Figure 10, Annex B, D.1.1.1, D.1.9.2, H.20, H.20.1.9.1, H.20.1.9.2, H.20.1.9.3, H.20.1.9.4, H.27.1.3, Annex L, Annex N, Q.4.2, R2.1 Annex S example A
Clutch	2.8.7
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Combination insulation-encased/metal encased class II control	2.7.5.3
Common error mode	H.2.20.1, H.11.12.6
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Creepage distance	1.5, 2.12, 2.12.2, 2.12.9.2, 10.1.4.2, 10.1.5, 10.2.3, 11.2.2, 11.2.3.1, 11.7.2.14, 11.9.1.1, 12.1.2, 14.7.4, 18.1.5, 20, 20.1, 20.1.6, 20.2, 20.2.1, 20.2.2, Table 20.3, Table 20.4, 20.2.3, 20.2.4, Annex B, D.1.9.2, H.20, H.20.1.9.1, H.20.1.9.2, H.20.1.9.3, H.20.1.9.4, H.27.1.3, Annex N, P.4.3.1, Annex S example B
Cycle of contact operation	2.3.25
– D –	
Data redundancy	H.2.18.2, H.2.18.2.1, Table H.11.12.7 items 1.5, 5.1, 6.1
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Detachable part	2.7.7, 2.7.8, 7.4.1, 8.1.1, 8.1.6, 8.1.7, 8.1.8, 8.1.9, 9.5.1, 11.11.1.5.4, 12.1.5, 12.2.6, 20.1, 20.2.1, 20.2.2
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Drift	2.6.1, 2.6.2, 2.11.2, 4.3.4.2, Table 7.2 item 42, 11.4.3, 15, 15.1, 15.4, 15.5.7, 15.6.1, 15.6.4, 16.2.4,17.1.2, 17.6.2, 17.14, H.27.1.4, J.7, J.12.2.1, J.15
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Dual channel (diverse) with comparison	H.2.16.2, H.11.12.2, Table H.11.12.7
Dual channel (homogeneous) with comparison	H.2.16.3, H.2.18.15, H.11.12.2
Duty cycle	2.2.7, 2.3.24, D.1.1
Dynamic analysis	H.2.17.1, Table H.11.12.6

Definition	Clause/subclause number
– E –	
Electrical control	1.1, 1.1.1, 1.1.2, 1.1.3, 2.2.1, H.4.1.9
Electrically operated control	2.2.12, 2.8.6, 6.3.10, 15.6
Electrically operated valve	2.2.17, 2.8.6, 6.3.12
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Electronic assembly	H.2.5.9
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Definition	Clause/subclause number
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– K –	

Definition	Clause/subclause number
– L –	
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Definition	Clause/subclause number
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NTC thermistor	1.4, J.2.15.3, J.2.15.4, J.2.15.6, J.6.4.3.3, J.17.8.6
– O –	
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Operating value	1.1.1, 2.3.11, 2.3.14, 2.3.17, 2.3.21, 2.3.26, 2.6.1, 2.6.2, 2.11.1, 2.11.2, 4.3.4.1, 4.3.4.2, 4.3.5.2, 6.4.3.10, Table 7.2 item 48, 11.4.2, 11.4.3, 11.4.13, 14.1.1, 14.4.3.3, 14.4.4.1, 15.1, 15.5.6, 15.6.2, 17.1.2, 17.9.3, 17.14
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– P –	
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Protocol test	H.2.18.14, Table H.11.12.7 items 5.1, 6, 6.2
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Pull-cord	2.5.6, 2.8.5, 11.3.9, 11.11.6, 18.7.2
Pull-cord actuated control	2.5.6, 11.3.9, 18.7, 18.7.1

Definition	Clause/subclause number
– Q –	
– R –	
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Rated voltage	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.5, 4.3.2.6, 5.1, 7.2.9, Table 7.2 item 3, 8.3.2.1, 10.1.4.2, 11.4.10, 11.7.1.2.1, 12.3.1, 12.3.3, 13.3.2, 14.4.3, 17.2.2, 17.2.3.2, Table 17.2-2, Table 17.2-3, 20.2.1, Table 20.3, 24.1.1, 27.2.1, 27.3, D.2.14.1, D.2.22.1, H.11.4.16.1, H.26.5.2, H.26.8.5, Table H.26.10.4, H.27.1.1, J.17.18.2, Table K.2
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Response value	1.3, 2.3.14, 7.4.4, 15.5.3
– S –	
Saddle terminal	2.9.12
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Same polarity	2.1.7
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Definition	Clause/subclause number
Sensing control	2.2.4, 2.2.6, 2.2.7, 2.2.8, 2.3.11, 2.4.3, 2.8.1, 4.3.4.2, 6.3.9, 6.4.3.5, Table 7.2 items 37, 38, 9.5.2, 10.2.4.2, Table 13.2 note 4, 14.4.3.1, 14.4.3.2, 15.5.2, 15.5.5, 15.6, 17.9.3, 23.1.1, H.2.4.6
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Single channel with functional test	H.2.16.5, H.11.12.2
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Single channel with periodic self test and monitoring	H.2.16.7, H.11.12.2, Table H.11.12.7-1
Slow-make slow-break automatic action	2.3.5
Software diversity	H.2.18.19, H.11.12.3
Software fault/error detection time	H.2.17.6, H.2.17.10, Table 7.2 item 71
Solder termination	2.9.11
Special purpose tool	2.8.8, 2.9.10, 2.10.6.1, 2.10.6.2, 2.13.3, 10.1.1, 10.1.1.1, 11.7.2.4, Table 19.1
Static analysis – hardware	H.2.17.7.1
Static analysis – software	H.2.17.7.2
Static memory test	H.2.19.6, H.2.19.6.1, H.2.19.6.2, Table H.11.12.7 items 1.1, 4.2
Stuck-at fault model	H.2.18.4, H.2.18.20
Stud terminal	2.9.3, 2.9.13, Figure 10
Supplementary insulation	2.7.5.3, 2.7.11, 2.7.13, 8.2.3, 8.3.1, 10.1.12, 11.2.1, 11.2.1.1, 11.2.2, 11.2.4, 11.7.2.2, 11.11.4, 11.11.5, 13.1.2, 13.2.2, Table 14.1, 18.1.5, 20.1.8, 20.1.9, 20.2.3, 20.3.2, H.20.1.9.3, H.27.1.3
Switch head	2.3.30, 2.8.2, 6.4.3.10, 6.7, 6.7.1, 6.7.2, 7.2.9, Table 7.2 item 22, 11.3.2, 11.4.13, 14.5.1, 14.6, 14.7, 17.3.1, 17.3.2
Systematic test	H.2.17.8, H.2.17.8.1, H.2.17.8.2, H.2.8.5, H.11.12.6.1
– T –	
Tab	2.9.5, 2.9.7, 2.9.8, 2.9.9, 10.2.4.1, Table 10.2.4.2, Table 10.2.4.3, 10.2.4.4, Figure 10
Tab forming part of a control	2.9.9

Definition	Clause/subclause number
Termination	2.9, 2.9.10, 2.9.11, 2.10.4, 9.1.1, 9.1.2, 9.1.3, 9.2, 9.3.1, 10, 10.1, 10.1.1.1, 10.1.3, 10.1.7.1, 10.2, 10.2.1, Table 10.2.1, 10.2.2, 10.3, 11.1.3.1, 11.1.3.2, 11.2.2, 14.2, Table 14.1, H.13.2, H.26.2.3, H.27.1.4
Tested monitoring	H.2.18.21, Table H.11.12.7 item 8, Table H.11.12.7-1 item 8
Testing pattern	H.2.18.22, Table H.11.12.7 items 1.4, 1.5, 4.3, 5.1, 5.2, 7.1, 7.2.1, 7.2.2, Table H.11.12.7-1 items 1.4, 7
Temperature limiter	2.2.7, 6.3.2, J.2.15.5
Thermal cut-out	2.2.8, 6.3.3, Table 7.2 note 17
Thermally operated control	2.2.5
Thermal motor protector	2.2.16, 6.3.11.1
Thermistor	1.4, 1.5, 2.15, 6.17, J.1.1.1, J.2.15, J.2.15.1, J.2.15.2, J.2.15.3, J.2.15.4, J.2.15.5, J.2.15.6, J.4.3.5.4, J.6.4.3.3, J.6.15.5, J.6.17, J.6.17.1, J.6.17.3, Table 7.2 item 61, J.12.2.1, J.13.2, J.17 a) & b), J.17.17.1, J.17.18, J.17.18.2, J.17.18.3.1, J.17.18.4, J.17.18.5, J.17.18.6, J.24.2.1
Thermistor control element	J.2.15.4, J.6.17.1, J.17.18.2
Thermistor sensing element	J.2.15.6, J.6.17.3, J.17.18.2
Thermostat	2.2.6, 6.3.1, 6.11.12 1), 10.2.1, Table 7.2 note 17
Time-based control	2.2.11, 2.2.12, 2.2.13, 2.2.14, 2.3.12, 2.8.6
Timer	2.2.13, 6.3.6, 15.6, D.1.12.1, H.2.18.10, Table 7.2 item 17
Time-slot and logical monitoring	H.2.18.10.3, H.2.18.22, Table H.11.12.7 items 1.3, 2, 3, 6.3
Time-slot monitoring of the programme sequence	H.2.18.10.4, H.2.18.22, Table H.11.12.7 item 1.3
Time switch	2.2.14, 6.3.7, Table 7.2 item 17
T_{max}	2.3.30, 6.7.1, 6.7.2, 7.2.7, Table 7.2 item 22, 14.5.1, Table 14.1 note 10, 17.3.1, 17.3.2, 21.2.6, 21.3.1, H.11.4.16.1, H.17.14.2 (c), Table P.4.1
Transfer redundancy	H.2.18.2, H.2.18.2.2, H.2.18.22, Table H.11.1.7 items 6, 6.2
Transient overvoltage	2.1.3, 2.1.11, 2.1.13, Annex L
Transmission	2.2.1, 2.2.2, 2.2.5, 2.2.11, 2.2.12, 2.2.17, 2.2.18, 2.3.1, 2.3.2, 2.3.4, 2.3.6, 2.8.6, D.2.6.2, H.2.18.18, H.11.12.5, Table H.11.12.7 item 6.3, Table H.11.12.7-1 item 6.3
Transparent GALPAT test	H.2.19.2, H.2.19.2.1, H.2.19.6.2, Table H.11.12.7 items 1.1, 4.2
Trip-free	2.3.15, 6.4.3.4, 6.4.3.5, 6.4.3.8, 6.4.3.9, 11.3.3
Two-step actuation	2.5.11
Type 1 action	2.6.1, 6.4.1, 6.4.3, Table 7.2 items 39, 40, note 4, 11.11.3.3, 17.7.3, 17.7.5, 17.8.4, 17.8.4.1, 17.13.5, H.17.1.4, H.26.2.1, H.26.2.2
Type 2 action	2.2.8, 2.6.2, 2.11, 6.4.2, 6.4.3, Table 7.2 items 39, 40, note 4, 11.4.2, 11.4.3, 11.11.3.2, 11.11.3.3, 15.1, 16.2.4, 17.1.2, 17.7.3, 17.9.3, 17.14, H.17.1.4.1, H.26.2, H.26.2.3, J.2.15.5
Type M attachment	2.10.6.2
Type X attachment	2.10.6.1
Type Y attachment	2.10.6.3
Type Z attachment	2.10.6.4
– U –	
Unique type reference	2.11.1, 2.13.1, 7.2.6, 7.2.7, Table 7.2 item 2, note 1
User	1.3, 2.2.6, 2.2.7, 2.2.8, 2.2.10, 2.3.7, 2.3.13, 2.3.18, 2.3.19, 2.3.20, 2.3.21, 2.8.3, 2.13.4, 2.13.5, 2.14, 2.14.4, 4.1.3, 7.2.1, 8.1.9.5, 8.4, 11.2.2, 11.3.8, 11.10.1, 11.11.1.1, 11.11.1.2, 11.11.2, 11.11.3.2, 11.11.4, A.1.2, A.1.3, D.1.11.2, D.2.11.1, D.2.22.1, H.7, H.11.12.12, H.17.1.4.2, H.28.2, R.3.2

Definition	**Clause/subclause number**
User maintenance	2.13.5, 2.14.4, 8.1.9.5, 8.4, 11.2.2, 11.11.1.1, 11.11.2, 11.11.4, H.28.2
– V –	
Variable memory	H.2.19.1, H.2.20.5, Table H.11.12.7-1 items 1.4, 1.5, 4.2
– W –	
Walk-through	H.2.17.5, H.2.17.9, H.11.12.6.1
Walpat memory test	H.2.19.7, Table H.11:12.7 items 1.1, 4.2, Table H.11.12.7-1 item 1.1
White box test	H.2.17.8, H.2.17.8.2, H.2.17.9
Word protection with multi-bit redundancy	H.2.19.8.1, Table H.11.12.7 items 1.1, 4.1, 4.2, 4.3, 5.1, 5.2, 6, 6.2
Word protection with single-bit redundancy	H.2.19.8.2, Table H.11.12.7 items 1.1, 4.1, 4.2, 4.3, 5, 5.2
Working voltage	2.1.3, 11.3.7.2, Table 13.2, 20.1.11, 20.2.2, Table 20.4, 20.3.2, J.17.18.5, P.4.3, Annex S examples A & B

AMENDMENT NO. 1

Page 2

CONTENTS

Add the following parenthesis after the title of Annex C: (not applicable in the countries members of CENELEC).

Add the following parenthesis after the title of Annex D: (applicable in Canada and the USA).

Page 13

1 Scope and normative references

1.1.1

Replace the third paragraph with the following new text:

This standard does not apply to automatic electrical controls intended exclusively for industrial applications unless explicitly mentioned in the relevant part 2.

1.1.2

Replace, at the end of the sentence, "voltage or acceleration" *by* "voltage, acceleration, or combinations thereof".

Page 15

1.5 Normative references

Add to the existing list the following references:

IEC 60326-3:1991, *Printed boards – Part 3: Design and use of printed boards*

IEC 60384-16:1982, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification – Fixed metallized polypropylene film dielectric d.c. capacitors*

IEC 60384-17:1987, *Fixed capacitors for use in electronic equipment – Part 17: Sectional specification – Fixed metallized polypropylene film dielectric a.c. and pulse capacitors*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test.* Basic EMC publication

IEC 61000-4-28:2002, *Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurement techniques – Variation of power frequency, immunity test.* Basic EMC publication

IEC 61210:1993, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61558-2-6:1997, *Safety of power transformers, power supply units and similar – Part 2: Particular requirements for safety isolating transformers for general use.* Group safety publication

Delete, on page 17, the following reference:

IEC 60742:1983, *Isolating transformers and safety isolating transformer. Requirements*

Page 19

2.1 Definitions relating to ratings, voltages, currents, and wattages

Replace the subclause heading with the following: "Definitions relating to ratings, voltages, currents, frequencies, and wattages."

Page 21

2.1.5

safety extra-low voltage (SELV)

Replace, on page 21, in the second note, "In some countries" *with* "In Canada and the USA".

Page 23

2.2 Definitions of types of control according to purpose

The amendment of the heading applies to the French version only.

Add, on page 27, after definition 2.2.20, the following new definitions:

2.2.21
multipurpose control
electrical control that can be classified and used for more than one purpose

An example of a multipurpose control is a thermostat that can also be used as a temperature limiter.

2.2.22
multifunctional control
electrical control which incorporates more than one function

An example of a multifunctional control is the combination of a thermostat and a humidistat.

Page 37

2.7.2 class 0 control

Replace, in the first note, "In some countries" *with* "In Austria, Belgium, Denmark, France, Germany, and the United Kingdom".

2.7.3 class 0I control

Replace, in the first note, "In some countries" *with* "In Austria, Belgium, Denmark, France, Germany, and the United Kingdom".

Page 57

4 General notes on tests

Add, after the existing paragraph, the following new explanatory notes:

If the results of any of the prescribed tests can be determined beyond doubt by assessment, then the test or tests need not be performed.

See also annex H. The requirements of annex H are not applicable to non-electronic controls, unless specified in an appropriate part 2 of this standard.

Page 59

4.2.1

Replace, in the third note, "In some countries" *with* "In Canada and the USA".

Page 65

6.1.1 Control for a.c. only

Modify the format of the second paragraph to an explanatory note.

Page 69

6.5 According to the degree of protection and control pollution situation

Replace the subclause heading with the following: "According to the degree of protection and control pollution degree."

Page 71

6.6.1

Replace "In some countries" *with* "In Canada and the USA" *in the* "in some countries" *note*.

Page 79

7.2 Methods of providing information

In Table 7.2, page 83, modify in the column "Information", *the lines numbered 3, 20, 21, 49 and 61 to 65 as follows:*

	Information	Clause or subclause	Method
3	Rated voltage or rated voltage range in volts (V)	2.1.2, 4.3.2 14.4.	C
20	Details of any special conductors which are intended to be connected to the terminals for internal conductors	10.2.1	D
21	Maximum temperature of terminals for internal conductors and terminals for external conductors of incorporated and integrated controls, if higher than 85 °C	14	X
49	Control pollution degree	6.5.3	D
61 to 65	See annex J		

Add the lines 78 to 81 as follows:

78	Maximum declared torque on single bush mounting using thermoplastic material	Table 19.1, note 1	D
79	Pollution situation in the micro-environment of the creepage or clearance if cleaner than that of the control, and how this is designed	Table H.27.1	D
80	Rated impulse voltage for the creepage or clearance if different from that of the control, and how this is ensured	Table H.27.1	D
81	The values designed for tolerances of distances for which the exclusion from fault mode "short" is claimed	Table H.27.1	D

Modify the notes of Table 7.2 as follows:

Replace, in the table inserted in note 4), the unit for the rate of change of humidity, from % HR/s *to* %/s.

Replace the sentence at the end of note 4) by the following sentence:

When using other activating quantities, the units shall be expressed in SI-units.

Notes 10 and 11:

Replace the existing text of notes 10 and 11 by "Void".

Page 91

7.4.3

Add the following new note:

In the United Kingdom, terminals intended exclusively for a live external conductor shall be indicated by the letter "L".

7.4.3.2

Replace "In the United States" *with* "In Canada and the USA" *in the first and second* "in some countries" *notes.*

Replace "In some countries" *with* "in Canada and the USA" *in the third note.*

Add a fourth note as follows

In the United Kingdom, the letter "L" shall not be used except as indicated in 7.4.3, above.

Page 93

8.1.1

Replace "In some countries" *with* "In Canada and the USA" *in the* "in some countries" *note.*

Page 99

8.4

Replace "In some countries" *with* "In Canada and the USA" *in the first and second notes.*

Page 101

9.3.2 Fixed wiring and methods X and M

Replace "In some countries" *with* "In Canada, China and the USA" *in the second note.*

Page 105

9.5.1 Detachable parts

Delete the "in some countries" *note.*

9.5.2 Incorporated control

Replace "In some countries" *with* "In the countries members of CENELEC" *in the* "in some countries" *note.*

Page 107

Table 10.1.4, note 1

In note 1, replace "In some countries" *with* "In the USA".

10.1.4.2

Replace "In the USA" *with* "In Canada and the USA" *in the* "in some countries" *note.*

10.1.4.3

Replace "In the USA" *with* "In Canada and the USA" *in the* "in some countries" *note.*

Page 115

10.1.14

Replace, "In some countries" *with* "In Canada and the USA" *in the* "in some countries" *note.*

Page 117

Table 10.2.1, note 1

Replace "In some countries" *with* "In the USA".

10.2.4 Flat push-on connectors

10.2.4.1

Add, on page 119, after the first paragraph, the following new text:

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may alternatively be used. The performance requirements of IEC 61210 do not apply.

Delete, on page 119, the "In some countries" *note.*

10.2.4.4

Add, on page 121, after the first paragraph, the following new text:

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may alternatively be used. The performance requirements of IEC 61210 do not apply.

Page 127

11.3.8 Contacts rest position

Add, at the end of the subclause, the following test specifications:

For the purposes of trying to obtain an intermediate position of an actuating member, between any indexed, marked, or intended rest positions, the actuating member should be actuated as in normal use. Holding the actuating member in position is not actuation.

Page 133

11.4.6 (erroneously numbered subclause following 11.4.15)

Renumber this subclause as 11.4.16.

11.5 Openings in enclosures

Replace, on page 133, "In some countries" *with* "In the USA" *in the third note.*

Page 141

Table 11.8.2, note 1

Replace "In some countries" *with* "In the USA".

Page 145

11.11.1.2

Replace "in some countries" *with* "in Canada and the USA" *in the first and fourth notes.*

Page 151

Add, after 11.12, on page 151, the following new subclause 11.13 as follows:

11.13 Protective controls and components of protective control systems

11.13.1 Protective controls

Protective controls shall

- be so designed and constructed as to be reliable and suitable for their intended duty and take into account the maintenance and testing requirements of the devices, where applicable,
- be independent of other functions, unless their safety function cannot be affected by such other functions,
- comply with appropriate design principles in order to obtain suitable and reliable protection.

These principles include, in particular, fail-safe modes, redundancy, diversity, and self-diagnosis.

Operating controls shall not be used as protective controls.

Compliance is checked by carrying out the relevant tests specified in this standard and the appropriate part 2.

NOTE A test method is under consideration.

11.13.2 Pressure limiting devices

These devices shall be so designed that the pressure will not permanently exceed the maximum allowable pressure of the controlled application; however, a short duration pressure surge of no more than 10 % of the pressure surge is allowable, where appropriate, or where not specified in the relevant standard for the controlled application.

11.13.3 Temperature monitoring devices

These devices shall have an adequate response time on safety grounds, consistent with measurement function.

Page 151

12.1.6

Replace, on page 153, "in some countries" with "in the USA" in the "in some countries" note.

Page 155

12.3

Add the following note:

NOTE In the countries members of CENELEC, this subclause does not apply.

Page 157

13.2 Electric strength

Replace the existing Table 13.2 by the following new table:

Table 13.2[14]

Insulation or disconnection to be tested [6] [10]	Test voltage for working voltages [11]					
	Class III up to 50 V [2]	Up to 50 V [1] or [2]	Over 50 V up to and including 130 V [1]	Over 130 V up to and including 250 V [1]	Over 250 V up to and including 440 V [1]	Over 440 V up to and including 690 V [1]
Operational insulation	100	100	260	500	880	1 380
Basic insulation [4] [7]	500	1 250	1 330	1 450	1 640	1 890
Supplementary insulation [4] [7] [8]		1 250	1 330	1 450	1 640	1 890
Reinforced insulation [4] [7] [8] [9]	100	2 500	2 660	2 900	3 280	3 780
Electronic disconnection [16]		100	260	500	880	1 380
Micro-disconnection [5]	500	100	260	500	880	1 380
Full-disconnection [5]		1 250	1 330	1 450	1 640	1 890
Micro-interruption [3]	-	-	-	-	-	-

[1] Applies to controls galvanically connected to mains.

[2] No requirement up to 24 V a.c. r.m.s. if the circuit is insulated from the mains by double or reinforced insulation (may be earthed).

[3] There are no electric strength requirements for micro-interruption, since the satisfactory completion of the tests of Clauses 15 to 17 inclusive are considered to be sufficient. Furthermore, for a control which has no micro-disconnection in one position of its actuating means and micro-interruption in other positions, there are no requirements for electric strength for those positions corresponding to micro-interruption.

[4] See 13.3.1.

[5] For the test of full-disconnection and micro-disconnection, contacts are opened automatically or manually and tested as soon after opening as possible to ensure that the contact separation and the supporting insulation are satisfactory.

In the case of temperature-sensing controls, it may be necessary to provide special samples specially calibrated to open between 15 °C and 25 °C to enable this test to be carried out at room temperature immediately after removal from the humidity cabinet.

[6] Special components which might render the test impractical, such as electronic parts, neon lamps, coils or windings shall be disconnected at one pole or bridged as appropriate to the insulation being tested. Capacitors shall be bridged except for the tests for operational insulation when one pole is disconnected. Where such a proceeding is not practical, the tests of Clauses 15 to 17 inclusive are considered to be sufficient.

[7] Any metal in contact with accessible metal is also regarded as accessible.

[8] For the tests of supplementary and reinforced insulation, the metal foil is applied in such a way that sealing compound, if any, is effectively tested to accessible insulating surfaces.

[9] For controls incorporating reinforced insulation as well as double insulation, care should be taken that the voltage applied to the reinforced insulation does not over-stress the basic or the supplementary parts of the double insulation.

[10] For class I and class 0I controls and controls for class I situations, care must be taken that adequate clearance is maintained between metal foil and accessible metal to avoid over-stressing of insulation between live parts and earthed metal parts.

[11] The high-voltage transformer used for the test must be so designed that when the output terminals are short-circuited after the output voltage has been adjusted to the test voltage, the output current is at least 200 mA. The overcurrent relay must not trip when the output current is less than 100 mA. Care shall be taken that the r.m.s. value of the test voltage is measured within ±3 %. See also Annex H.

[12] to [13] See Annex H.

[14] In Canada and the USA, other values are applicable.

[15] See Annex H.

[16] See Clause H.28.

Page 161

13.3.4

Replace "in some countries" *with* "in Canada and the USA" *in the note.*

14.1.1

Replace "in some countries" *with* "in Canada and the USA" *in the note.*

Page 163

14.4

Replace "In some countries" *with* "In the USA" *in the note.*

Page 167

Table 14.1

Modify the column "Parts" as follows:

- *on the line* "Windings 8) 9) 10) 11) 13) and core laminations in contact therewith, if winding insulation is:" *delete the reference to note 11;*
- *on the line* "Terminals and terminations for external conductors", *add, after reference to notes 1 and 7, a reference to note 14, marked by mean of "14)";*
- *on the line* "Current carrying parts made of copper or brass" *on page 169, add, after reference to note 1, a reference to notes 6 and 15, marked by mean of "6) 15)"*

Notes to table 14.1

Replace, on page 169, "in some countries" *with* "in Canada and the USA" *at the end of note 1.*

Replace "in some countries" *with* "in the USA" *in the second paragraph of note 7.*

Replace the text of note 11, on page 171, with "Void".

Add after note 13), on page 171, the following new notes 14) and 15):

14) For incorporated and integrated controls, no temperature limit is applicable, but attention is drawn to the fact that most equipment standards limit the temperature of terminals of fixed appliances to 85 °C, which is the maximum allowable temperature for ordinary PVC cable insulation. The maximum temperature recorded should not exceed the value declared in Table 7.2, item 21.

When a control is incorporated/integrated into an appliance, the terminals for external conductors will, as part of the appliance, be subject to the specified tests of the appliance standard and assessed for compliance with the temperature limits of that standard.

15) Higher temperatures are acceptable for specific copper alloys if substantiated by test data from the alloy manufacturer to a recognized metallurgical standard. See also note 6.

Page 173

15.1

Replace "In some countries" *with* "In Canada and the USA" *in the note.*

Page 175

16.2 Environmental stress of temperature

16.2.1

Revise the value of the temperature in the first dashed paragraph to (–10 ± 2) °C.

Replace "in some countries" *with* "In Finland, Norway, and Sweden" *in the note.*

Page 177

17.1.3.1

Replace "in some countries" *with* "in the USA" *in the parenthesis at the end of the second and fifth bullet.*

Page 179

17.2.2

Replace "In those countries which use an overvoltage test" *with* "In all countries which use an overvoltage test except Canada, China and the USA.".

17.2.3

Replace "In those countries which use an overload test" *with* "In all countries which use an overload test except Canada, China and the USA.".

17.2.3.1

Replace "In some countries" *with* "In all countries except Canada, China and the USA".

Page 181

Table 17.2.1

Replace the existing table title with the following new title:

Table 17.2.1 – Electrical conditions for the overvoltage test
(this table applies in all countries except Canada, China, and the USA)

Page 183

Table 17.2.2

Replace the existing table title with the following new title:

Table 17.2.2 – Electrical conditions for the overload tests of 17.7 and 17.10
(this table applies in Canada, China, and the USA)

Page 185

Table 17.2.3

Replace the existing table title with the following new title:

Table 17.2.3 – Electrical conditions for the overload tests of 17.8, 17.9, 17.11, 17.12 and 17.13 (this table applies in Canada, China, and the USA)

Page 189

17.5.1

Replace "In some countries" *with* "In Canada and the USA" *in the note.*

17.6.2

Replace "In some countries" *with* "In Canada and the USA" *in the note.*

Page 191

17.7.7

Replace, in the second paragraph, "In some countries" *with* "In Canada and the USA".
Page 193

17.8.4.1

Replace, in the note, "In some countries" *with* "In Canada and the USA".

17.10 Overvoltage (or in some countries, overload) test of manual action at accelerated speed

Replace the existing title with the following new title:

17.10 Overvoltage (or in Canada, China and the USA, overload) test of manual action at accelerated speed

17.10.4

Replace "In some countries" *with* "In Canada and the USA".

Page 195

17.12.5

Replace "In some countries" *with* "In Canada and the USA".

17.14

Replace in the second dash "In some countries" *with* "In Canada and the USA".

Page 197

18 Mechanical strength

18.1.6

Replace, on page 199, "In some countries" *with* "In Canada and the USA".

18.1.6.1

Replace "In some countries" *with* "In Canada and the USA".

18.1.6.2

Replace "In some countries" *with* "In the USA".

18.1.6.3

Replace in the first paragraph "In some countries" *with* "In Canada and the USA".

Page 201

18.4 Alternate compliance – Impact resistance

Replace, in the note, "In some countries" *with* "In Canada and the USA".

Page 209

19.1 Threaded parts moved during mounting or servicing

Table 19.1

Replace, on page 213, note 1) of Table 19.1 as follows:

[1] Nuts and threaded rings of greater than 4,7 mm in diameter which are used for single-bush mounting are tested with a torque of 1,8 Nm, except that, for controls for single-bush mounting using thermoplastic materials and where there is no torque effected on the mounting for setting or resetting (i.e. for thermal cut-outs), the thread for mounting is tested with the maximum torque as declared by the manufacturer which in no case shall be less than 0,5 Nm.

Page 215

19.2.4.1

Replace, in the note, "In some countries" *with* "In Canada and the USA".

19.2.5.1

Replace, in the note, "In some countries" *with* "In Canada and the USA".

Page 219

Table 20.2 – Clearances for insulation co-ordination (from IEC 60664-1, Table 2)

Modify Table 20.2 as follows:

Rated impulse voltage from table 20.1 1) kV	Clearances in air up to 2 000 m above sea-level mm							
	Case A				Case B (impulse test required – see 20.1.12)			
	Pollution degree 2)				Pollution degree 2)			
	1	2	3	4	1	2	3	4
0,33	0,01	0,20	0,8	1,6	0,01	0,2	0,8	1,6
0,50	0,04				0,04			
0,80	0,10				0,1			
1,5	0,5	0,5			0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3

1) For operational insulation, the rated impulse voltage is derived from the value in column 3 of Table 20.1 which covers the measured voltage across the clearance, unless otherwise declared and justified by the manufacturer. If the secondary winding of the stepdown transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the reference for the rated impulse voltage for the clearances of basic insulation on the secondary side shall be one step lower than that which covers the rated input voltage of the primary side of the transformer.

The use of an isolating transformer without an earthed protective screen does not allow a reduction in the rated impulse voltage.

2) An explanation of pollution degree is given in Annex N.

3) For altitudes of more than 2 000 m above sea-level, the values for clearances shall be multiplied with the correction factor specified in IEC 60664-1, Table A.2.

NOTE For small values of clearances, the uniformity of the electric field can deteriorate in the presence of pollution, making it necessary to increase the clearance values above the values of case B.

Page 221

20.1.6.1

Delete the last paragraph and the following note.

20.1.7

Add at the end of the subclause, a new paragraph and a new note, as follows:

When testing operational insulation, the impulse voltage is applied across the clearance.

NOTE When carrying out the impulse test, it may be necessary to disconnect parts or components of the control.

Page 223

Add, after 20.1.12, the new subclause 20.1.13 as follows:

20.1.13 If the secondary of a transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the clearances of basic insulation on the secondary side shall not be less than those specified in Table 20.2 but using the next lower step for rated impulse voltage as a reference.

NOTE The use of an isolating transformer without an earthed protective screen or earthed secondary does not allow a reduction in the rated impulse voltage.

For circuits supplied with a voltage lower than rated voltage, for example, on the secondary side of a transformer, clearances of functional insulation are based on the working voltage, which is used as the rated voltage for Table 20.1.

Page 229

20.3.1

Delete the second paragraph including the two bullets.

20.3.2

Replace subclause 20.3.2 by the following new subclause:

20.3.2 The distance through insulation for supplementary and reinforced insulation, for working voltages up to and including 300 V, between metal parts shall not be less than 0,7 mm.

This does not imply that the distance has to be through insulation only. The insulation may consist of solid material plus one or more air layers.

For controls having parts with double insulation where there is no metal between basic insulation and supplementary insulation, the measurements are made as though there is a metal foil between the two layers of insulation.

20.3.2.1 The requirement of 20.3.2 does not apply if the insulation is applied in thin sheet form, other than mica or similar scaly material.

- For supplementary insulation, it consists of at least two layers, provided that each of the layers withstands the electric strength test of 13.2 for supplementary insulation.
- For reinforced insulation, it consists of at least three layers, provided that any two layers together withstand the electric strength test of 13.2 for reinforced insulation.

Compliance is checked by inspection and by test.

20.3.2.2 The requirement of 20.3.2 does not apply if the supplementary insulation or the reinforced insulation is inaccessible and meets one of the following criteria.

- The maximum temperature determined during the tests of Clauses 27 and H.27 does not exceed the permissible value specified in Table 14.1.
- The insulation, after having been conditioned for 168 h in an oven maintained at a temperature equal to 25 K in excess of the maximum temperature determined during the tests of Clause 14, withstands the electric strength test of 13.2, this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

For optocouplers, the conditioning procedure is carried out at a temperature of 25 K in excess of the maximum temperature measured on the optocoupler during the tests of Clauses 14, 27 and H.27, the optocoupler being operated under the most unfavourable conditions which occur during these tests.

Compliance is checked by inspection and by test.

Page 231

21 Resistance to heat, fire and tracking

21.1

Replace "In the United States" *with* "In Canada and the USA" *in the note.*

Page 237

21.4

Add the following note:

NOTE In the countries members of CENELEC, this subclause does not apply.

Page 243

24 Components

24.1

Replace the first paragraph of 24.1 by the following:

24.1 Transformers intended to supply power to a safety extra-low voltage circuit (SELV) shall be of the safety isolating type and shall comply with the relevant requirements of IEC 61558-2-6.

24.1.1

Replace in the first paragraph "transformer" *with* "safety isolating transformer" *and* "SELV circuit" *with* "isolated limited secondary circuit".

Page 253

Figure 4 – Impact test for free-standing controls

Revise the clause reference for the table for the pull to be applied from "12.7.2" *to* "11.7.2".

Page 269

Figure 11 – Pillar terminals

In the table following Figure 11, on page 271, in the column "Current carried by terminal – For fixed conductor", *replace* "0,6" with "0-6".

Page 277

Figure 14 – Tabs

Replace the existing table in Figure 14 by the following new table:

Dimensions in millimetres

Dimension **For figures 14 7) and 15 7)**	**Connector size**			
	2,8	**4,8**	**6,3**	**9,5**
l_1 (min.) 1)	7,7	6,9	8,6	14,0
l_2 (min). 1)	7,0	6,2	7,9	12,0
l_3 (max.) 2)	3,0	5,2	6,7	8,2
l_4	1,0 ± 0,2	2,5 ± 0,25	3,2 ± 0,3	4,2 ± 0,3
l_5 (max.)	0,7	1,2	1,3	1,7
l_6 (max.)	0,7	1,2	1,3	1,7
b_1 (hole)	$1{,}2^{+0{,}1}_{0}$	$1{,}4^{+0{,}2}_{0}$	$1{,}6^{+2{,}0}_{0}$ 3)	$2{,}1^{+2{,}0}_{0}$ 3)
b_1 (slot)	$1{,}2^{+0{,}1}_{0}$	$1{,}4^{+0{,}2}_{0}$	$1{,}6^{+0{,}1}_{0}$	$2{,}1^{+0{,}2}_{0}$
b_2	2,8 ± 0,1	4,75 ± 0,2	$6{,}3^{+0{,}15}_{-0{,}1}$	$9{,}5^{+0{,}15}_{-0{,}1}$
b_3 (min.) 4)	2,0	2,0	2,5	2,5
t 5)	0,5 ± 0,025	0,8 ± 0,03	0,8 ± 0,03	1,2 ± 0,03
p (max.) 6)	0,8	1,2	1,2	1,7
k	–	$0{,}7^{0}_{-0{,}1}$	$1{,}0^{0}_{-0{,}1}$	$1{,}5^{0}_{-0{,}1}$
x	–	1,0 ± 0,2	1,0 ± 0,2	1,4 ± 0,2

NOTE The sketches are not intended to govern design except as regards the dimensions shown.

1) In order to provide sufficient clearance for receptacles intended to be provided with a sleeve, it may be necessary to increase this dimension by 0,5 mm to ensure that the means of location operates correctly.

2) The length of the slot (l_3-l_4) must be at least equal to its width (b_1).

3) These tolerances are chosen so as to allow the tabs to be used as a part of a terminal with screw clamping.

4) Over the double-hatched area, the thickness shall not exceed the upper limit of the material thickness specified.

5) With the exception of the dimple or hole and the area indicated by dimension "b", the thickness "t" shall be maintained over the whole connecting area. Compliance shall be determined by measurement over any section (3,2 ± 0,2) mm², in a circular area. In addition, the overall flatness shall have a tolerance of 0,03 mm.

6) This dimension applies only to the raised side of the tab; on the reverse side, the flatness tolerance extends across the full width of the tab.

7) Tabs may have an optional detent for latching. Round dimple detents, rectangular dimple detents and hold detents shall be located in the area bounded by dimensions b_1, l_3 and l_4 along the centre line of the tab.

Tabs may be manufactured from more than one layer of materials, provided that the resulting tab complies with this standard.

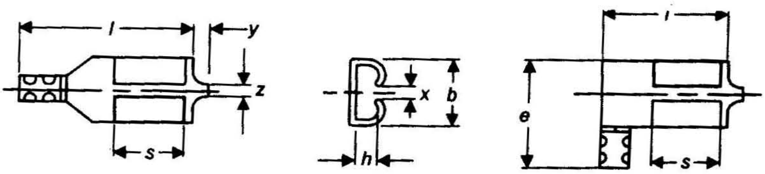
Details for tabs having corrugations or depressions are under consideration.

Figure 14 – Tabs

Page 281

Figure 16 – Receptacles

Replace Figure 16 as follows:



Dimensions in millimetres

Dimension	Connector size			
	2,8	4,8	6,3	9,5
b (max.)	4	6	8	12,5
e (max.)	12	12	15	20
h (max.)[1]	1	2	2,5	3,2
l (max.)	18	18	22	27
s (min.)	4,5	5	6	10
x (min.)[2]	-	0,9	1,2	1,7
y (max.)	0,5	0,5	0,5	1,0
z (max.)	1,5	1,5	2,0	2,0

[1] Maximum offset dimension from the centre line of the tab blade.

[2] Applies only to receptacles for non-reversible connectors.

The dimensions shown apply to the crimped condition.

Dimensions for receptacles provided with a sleeve and for receptacles with a pre-insulated barrel are under consideration.

The sketches are not intended to govern design except as regards the dimensions shown.

Figure 16 – Receptacles

Page 291

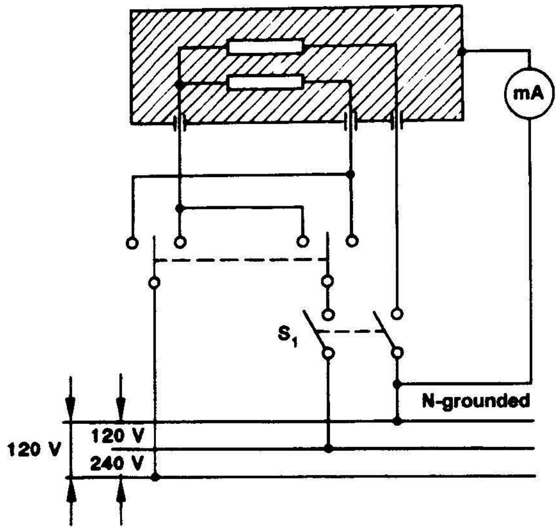


Figure 30 – Diagram for leakage current measurement at operating temperature for two-phase connection of control to three-wire, ground neutral supply other than class II

Add "mA" *in the circle indicating the measuring instrument.*

Page 305

Annex C
(normative)

Add the following parenthesis to the title of the annex:

(not applicable in the countries members of CENELEC)

Page 307

Annex D
(informative)

Heat, fire and tracking
(applicable in the USA)

Replace, in the parenthesis included in the title, "in the USA" *with* "in Canada and the USA".

Page 361

Annex G
(normative)

Heat and fire resistance tests

G.2 Glow wire test

Add, at the end of the clause, the following dash:

- *It shall be noted in the test report, whether any ignition or flame occurs or not.*

Page 363

G.4 Proof tracking test

Replace, in the third indent of the second paragraph, "30.5" *with* "30".

Page 365

Annex H
(normative)

Requirements for electronic controls

H.2 Definitions

H.2.5 Definitions of type of control according to construction

Add, on page 367, after H.2.5.10, the following new definition:

H.2.5.11
hybrid circuit
circuit produced on ceramic substrate by means of thick film, thin film or surface-mounted devices (SMD) technology, without accessible electrical connections except for I/O points, and with all internal connections constructed as part of a lead frame or other integral construction

Page 367

H.2.7 Definitions relating to protection against electric shock

H.2.7.14

The modification applies to the French version only.

Page 385

Add, after definition H.2.20.5, the following new definitions:

H.2.21 Definitions relating to software classes

H.2.21.1
software class A
control functions which are not intended to be relied upon for the safety of the equipment

Examples are room thermostats, humidity controls, lighting controls, timers and time switches.

H.2.21.2
software class B
control functions intended to prevent unsafe operation of the controlled equipment

Examples are thermal cut-outs and door locks for laundry equipment.

H.2.21.3
software class C
control functions which are intended to prevent special hazards (for example, explosion of the controlled equipment)

Examples are automatic burner controls and thermal cut-outs for closed water heater systems (unvented).

Page 393

H.8 Protection against electric shock

H.8.1 General requirements

H.8.1.10

Modify the existing subclause H.8.1.10 as follows:

H.8.1.10 Accessible parts shall not be considered as hazardous live parts if separated from the supply by protective impedance.

H.8.1.10.1

The modification applies to the French version only.

H.11.2 Protection against electric shock

H.11.2.5

Replace the existing subclause H.11.2.5 by the following:

H.11.2.5 Protective impedance shall consist of two or more impedance components of equivalent resistance values in series, which are connected between live parts and accessible parts. It shall consist of components in which the probability of a reduction in impedance during life can be ignored and the possibility of a short circuit is negligible.

Such components are resistors pointed out in Table H.27.1, note 13.

Alternatively, the resistors shall comply with the requirements of 14.1 of IEC 60065.

Compliance is checked by

a) open-circuiting each impedance component in turn;

b) short-circuiting of those impedance components which are likely to fail by a short (according to Clause H.27);

c) applying a fault condition according to Clause H.27 to any part of the circuit which might influence the maximum leakage current with the protective impedance intact ;

Operation of a protective device or loss of one pole of the supply shall also be considered as faults.

Under these conditions, the equipment shall still comply with the requirements of H.8.1.10.

Page 397

H.11.12.6

Replace "in the USA" *with* "in Canada and the USA" *in the* "in some countries" *note.*

Page 411

H.13.2 Electric strength

Addition to Table 13.2:

Replace, in the second line, "120" *by* "100".

The modification of note 12 applies to the French version only.

Page 415

H.20.1.9.3

The modification applies to the French version only.

H.26 Electromagnetic compatibility (EMC) requirements – Immunity

H.26.1

Replace the existing subclause H.26.1 by the following:

H.26.1 Electronic controls shall be so constructed as to withstand the effects of mains-borne perturbations and electromagnetic phenomena which may occur in normal use.

Evaluation criteria for the control appropriate to test level 2 and/or 3 shall be given by the appropriate part 2. Refer to all subclauses in H.26.15 for additional details. These levels correspond with severity levels specified by the IEC 61000 series. The part 2 shall provide acceptable effects on the control as a result of tests using severity levels 2 and/or 3, such as normal operation after level 2 test and safe operation of appliance/safe shut-down after level 3 test. Parts 2 may specify higher severity levels.

The part 2 shall specify severity levels for Clause H.26 tests. As a minimum, test Level 3 is applicable to protective controls intended to prevent unsafe operation of the controlled equipment, such as cut-outs and door-locks for laundry equipment, and burner controls. As a minimum, test level 2 is applicable to operating controls relied on for the normal operation of the equipment, such as thermostats, timers.

The tests of Clause H.26 are not applicable to non-electronic controls because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic controls may be included in other clauses of the appropriate part 2.

H.26.2

Replace H.26.2 and H.26.2.1 by the following subclause H.26.2:

H.26.2 For protective and operating controls with either type 1 or 2 action, and either integrated, incorporated, independently mounted, or free-standing, compliance is checked at test levels as indicated by the following Table H.26.2.1. The controls shall comply with H.26.15.

Table H.26.2.1 – Applicable test levels

Control type	Type action	Construction	Applicable clause H.26 tests	Applicable test levels of IEC 61000-4
Operating control	Type 1	Integrated/incorporated, or Independently mounted or free- standing	26.8, 26.9	2
Operating control	Type 2	Integrated/incorporated or Independently mounted or free- standing	26.4 to 26.13	2
Protective control	Type 2	Integrated/incorporated or Independently mounted or free- standing	26.4 to 26.13	2 and 3

H.26.2.2 *Renumber this subclause as H.26.2.1.*

H.26.2.3 *Renumber this subclause as H.26.2.2.*

Page 423

H.26.5 Test of the influence of voltage dips and voltage interruptions in the power supply network

Replace the title and text of the existing subclause H.26.5 including subclauses H.26.5.1 to H.26.5.6 by the following new subclause H.26.5 as follows:

H.26.5 Voltage dips and voltage interruptions in the power supply network

The control shall tolerate voltage dips and voltage interruptions in the power supply network.

Compliance is checked by the tests of H.26.5.2 to H.26.5.3 inclusive.

H.26.5.1 Purpose of the test

The purpose of the test is to verify the immunity of the equipment against voltage dips and voltage interruptions. Voltage dips and interruptions are caused by faults in the LV, MV, HV networks (short-circuit or ground faults).

H.26.5.2 Test values

The test values in table H.26.5.2 shall be applied to all the test levels.

Table H.26.5.2 – Test values for voltage dips and interruptions

	ΔU (Reduction)	Duration
Voltage dips	30 %	0,5 s
	60 %	0,5 s
Voltage interruptions	100 %	1 cycle of supply wave form 0,5 s 60,0 s

NOTE Where intermediate durations of voltage interruption may affect either the inherent safety of the control or the output of a type 2 control, parts 2 may indicate voltage interruptions at other points.

H.26.5.3 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-11. During the test, the control shall be initially operated at its rated voltage.

The voltage dips and interruptions, at random phase with respect to the mains frequency, shall be performed at least three times in the relevant operating modes.

Attention should be given to the operating modes in which the control may be particularly sensitive to voltage dips and interruptions.

Between the voltage dips and interruptions a waiting time of at least 10 s shall be observed.

In the case of three-phase equipment, it may be necessary to apply voltage dips and interruptions either on the three phases simultaneously or on one or two phases only.

H.26.5.4 Voltage variation test

The control shall tolerate short-term supply voltage variations.

Compliance is checked by the test of H.26.5.4.

H.26.5.4.1 Purpose of the test

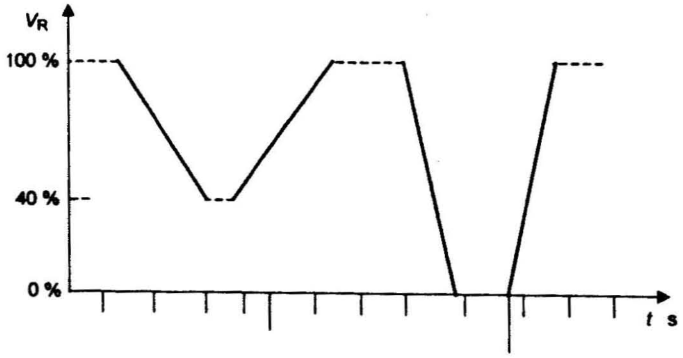
The purpose of the test is to verify the immunity of the control against voltage change taking place over a short period which may occur due to a change of load or stored energy in local power networks.

H.26.5.4.2 The duration and procedure

The duration of the voltage changes and the time for which the reduced voltages are to be maintained are given in Table H.26.5.4.2 and illustrated in Figure H.26.5.4.2. The rate of change of voltage shall be constant; however, the voltage is able to be stepped. The steps shall be positioned at 0 crossing and shall be not larger than 10 % of V_R. Steps under 1 % of V_R are evaluated as constant rate of change of voltage.

Table H.26.5.4.2 – Timing of short-term supply voltage variations

Voltage test level	Time for decreasing voltage	Time at reduced voltage	Time for increasing voltage
40 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
0 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
	x	*x*	*x*
NOTE *x* represents an open set of durations and is able to be specified in part 2.			



NOTE The voltage gradually decreases.

Figure H.26.5.4.2 – Voltage variation test

H.26.5.4.3 The control is subjected to each of the specified voltage test cycles three times with 10 s intervals between each test cycle for the most representative modes of operation. Additional voltage test levels may be specified in part 2.

Page 425

H.26.6.4 Severity level

At the end of the sentence, delete "(2)".

H.26.8 Surge immunity test

Replace the whole of existing subclause H.26.8 including subclauses H.26.8.1 to H.26.8.5 by the following:

The control shall tolerate voltage surges on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.26.8.2 to H.26.8.3 inclusive.

H.26.8.1 Purpose of the test

This test applies to the power supply terminals and in specific cases to the control terminals (see H.26.8.2).

Controls providing electronic disconnection are loaded as indicated in 17.2 and subjected to the test as levels for the installation class specified for the control by the manufacturer, when the control is providing electronic disconnection. During and after the test, the control shall continue to provide electronic disconnection, as determined by the test of H.11.4.16.2. If, during the test, the electronic disconnection is caused to be conductive for one-half cycle of the supply frequency after application of one surge, this is not considered to be a fault.

The purpose of this test is to verify the immunity of the control against unidirectional surges caused by different phenomena:

- switching phenomena in the power network (for example, switching of capacitor banks);
- faults in the power network;
- lightning strikes.

The induced voltage surge can have different effects, depending on the relative impedance of the source and of the control:

- if the system has a high impedance relative to the source, the surge will produce a voltage surge;
- if the control has a relative low impedance, the surge will produce a current pulse.

This behaviour can be illustrated by an input circuit protected by an overvoltage suppressor: as soon as the latter breaks down, the input impedance becomes very low. A realistic test shall correspond to this behaviour and the test generator shall be able to deliver a voltage pulse on a high impedance as well as a current pulse on a low impedance (hybrid generator).

H.26.8.2 Test values

The tests as detailed in Table H.26.8.2 shall be applied.

The tests on the terminals for signal, data, control and other input lines shall only be performed if these terminals are designed to make an interconnection with cables longer than 10 m, according to the manufacturer's specifications.

Table H.26.8.2 – Test voltages for test level 2 (depending on the installation class conditions)

IEC 61000-4-5 installation class	Test values peak kV					
	Power supply		Unbalanced operated circuits and lines		Balanced operated circuits and lines	
	Coupling mode		Coupling mode		Coupling mode	
	Line to line	Line to earth	Line to line	Line to earth	Line to line	Line to earth
2	0,5	1,0	0,5	1,0	No Test	1,0
3	1,0	2,0	1,0	2,0	No Test	2,0
4	2,0	4,0	2,0	4,0	No Test	2,0

NOTE 1 For test level 3 requirements, apply the next higher installation class.

NOTE 2 Tests are performed with any intended surge suppression properly installed.

NOTE 3 In a control, a lower category may follow any higher category when appropriate transient overvoltage control means are provided.

NOTE 4 See Annex R for description of installation class and further explanatory notes.

H.26.8.3 Test procedure

The test apparatus and procedure shall be as described in IEC 61000-4-5. In accordance with this standard, the control is connected to an appropriate source of supply operating at the rated voltage with the impulse generator connected across the terminals.

The tests are carried out by subjecting the system to five pulses of each polarity, positive and negative (+, –), distributed over the relevant operating modes and with the voltage values listed in table H.26.8.2 at intervals not less than 60 s or as specified in the relevant part 2.

Page 427

H.26.9 Electrical fast transient/burst immunity test

Replace the existing subclause H.26.9 by the following:

H.26.9 Electrical fast transient/burst test

The control shall tolerate fast transient bursts on the mains supply and on the signal lines.

Compliance is checked by the test of H.26.9.2 to H.26.9.3 inclusive.

H.26.9.1 Purpose of the test

This test applies to the power supply terminals and in specific cases to the control terminals (see H.26.9.2).

The purpose of this test is to demonstrate the immunity of the control to bursts of fast low energy transients which may be produced by relays, contactors, etc., switch inductive loads and which may be induced into signal and data circuits.

H.26.9.2 Test levels

The test levels shall be applied in accordance with Table 1 of IEC 61000-4-4. Repetition frequency shall be 5 kHz. Tests shall be applied to inputs, outputs and data lines as specified in Table H.26.9.2.

The tests on the terminals for interface cables shall only be performed if these terminals are designed to make an interconnection with cables longer than 3 m, according to the manufacturer's specifications.

Generator drive:	*internal*
Duration	*1 min each positive (+) and also negative (–) polarity*
Operating conditions:	*as in the relevant part 2*

Table H.26.9.2 – Test application for electrical fast transient burst test

AC power supply and control outputs for direct connection to the supply		DC power supply and control outputs for direct connection to the supply	Data lines[1]
Direct between the reference ground plane and	Each power supply line, individually	Capacitive clamps[2]	Capacitive clamp
	The nearest protective earth terminal		
	To all multiple combinations of power supply lines and also earth line		

[1] Applicable only to lines greater than 3 m in length, according to the manufacturer's declaration.

[2] Not applicable to lines connected to dedicated non-rechargeable power supplies.

H.26.9.3 Test procedure

The test apparatus and test procedures shall be as described in IEC 61000-4-4.

The control is tested in each of the relevant operating modes, as specified in the relevant part 2.

Page 433

H.26.12 Radio-frequency electromagnetic field immunity

H.26.12.1 Purpose of the test

Replace the existing text of subclause H.26.12.1 by the following new text:

The purpose of the test is to verify the immunity of controls against electromagnetic fields generated by radio transmitters or any other device emitting continuous wave radiated electromagnetic energy. The immunity of controls to the radiation of hand-held transceivers (walkie-talkies) is the main concern but other sources of electromagnetic radiation are involved, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electro-magnetic sources of intermittent sources.

H.26.12.1.1 If the criticality of level 2 testing is not affected after level 3 testing, the testing of level 2 need not be carried out.

H.26.12.2 Immunity to conducted disturbances

Table H.26.12.2.1 – Test levels for conducted disturbances on mains and I/O lines

Replace the existing Table H.26.12.2.1 by the following new table:

(The modification of the title applies to the French version only.)

Frequency ranges: 150 kHz – 80 MHz		
Test level	Voltage level (emf)	
	U_e dBµV	U_e V
2	130	3
3	140	10
NOTE The levels in the ISM- and CB-bands are chosen to be 6 dB higher. (ISM: Industrial, scientific and medical radio-frequency equipment: 13,56 ± 0,007 MHz and 40,68 MHz ± 0,02 MHz, CB: Citizen band: 27, 125 MHz ± 1,5 MHz).		

Page 435

H.26.12.3 Immunity to radiated electromagnetic fields

Replace the existing title and text of subclause H.26.12.3 by the following new subclause:

H.26.12.3 Radiated electromagnetic fields immunity evaluation

The control shall tolerate high-frequency signals on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.26.12.3.1 to H.26.12.3.2 inclusive.

H.26.12.3.1 Immunity to radiated electromagnetic fields

Replace the existing Table H.26.12.3.1 by the following:

<table>
<tr><th colspan="2">Frequency ranges: 80 MHz to 960 MHz and 1,4 GHz to 2,0 GHz</th></tr>
<tr><th>Test level</th><th>Field strength
V/m</th></tr>
<tr><td>2</td><td>3</td></tr>
<tr><td>3</td><td>10</td></tr>
<tr><td colspan="2">NOTE The levels in the ISM- and GSM bands are chosen to be 6 dB higher.
ISM: Industrial, scientific and medical radio-frequency equipment: 433,92 ± 0,87 MHz.
GSM: Group special mobile 900 MHz ± 5,0 MHz modulated by 200 Hz = 2 % pulses of equal mark/space ratio (2,5 ms on and 2,5 ms off).</td></tr>
</table>

H.26.13 Evaluation of compliance

Replace the existing subclause H.26.13 including subclauses H.26.13.1 to H.26.13.3 by the following new subclause:

H.26.13 Test of influence of supply frequency variations

Micro-processor based controls utilizing software class B and/or C which rely on the mains supply frequency for the correct operation shall tolerate frequency variations of the mains supply frequency, if declared by the manufacturer in Table 7.2 of Clause H.7.

H.26.13.1 Purpose of the test

The purpose of this test is to verify the effect on the control from frequency deviation on the mains.

H.26.13.2 Test levels

The test values in table H.26.13.2 shall be applied.

Table H.26.13.2 – Test values for supply frequency variations

Variations in supply frequency %	Test level 2	Test level 3
–5		X
–4		X
–3		X
–2	x	
–1	x	
+1	x	
+2	x	
+3		X
+4		X
+5		X
± other values [1]	[1]	[1]

[1] Other values may be specified in part 2.

H.26.13.3 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-28.

The control shall be initially operated at its rated voltage and shall then be subjected to the frequency variations as detailed in H.26.13.2.

H.26.14 Power frequency magnetic field immunity test

The controls which are susceptible to magnetic field such as controls which use Hall-effect devices shall tolerate power-frequency magnetic fields.

Compliance is checked by the tests of H.26.14.2.

Examples of such controls include pressure sensors which use Hall-effect devices, controls incorporating reed relays and controls utilizing bistable relays.

H.26.14.1 Purpose of the test

The purpose of the test is to demonstrate the immunity of controls which may be affected by power-frequency magnetic fields related to the specific location and installation conditions of the control (for example, proximity of the equipment to the disturbance source).

The power-frequency magnetic field is generated by power-frequency currents in conductors or from other devices (for example, leakage of transformers) in the proximity of equipment.

Only the influences of nearby conductors should be considered, where the current under normal operating conditions, produces a steady (continuous) magnetic field, with a comparatively small magnitude.

H.26.14.2 Test levels

The test levels shall be applied in accordance with the following table.

Table H.26.14.2 – Test level for continuous fields

Severity level	Continuous field strength
2	3 A/m
3	10 A/m

H.26.14.3 Test procedure

The control is supplied at rated voltage. Test equipment, test set-up and test procedure shall be in accordance with IEC 61000-4-8. The control is tested under the test conditions as specified in the relevant part 2.

H.26.15 Evaluation of compliance

H.26.15.1 After the tests of H26.2 through H.26.12, the sample(s) shall meet the requirements of Clause 6, Subclause 17.5 and Clause 20.

H.26.15.2 In addition, the control shall meet the following:

- the requirements of H.17.14 or
- the output(s) and functions shall be as declared in Table 7.2, requirements 58a and 58b.

Compliance with the second alternative of H.26.15.2 may make the control unacceptable for some applications.

Parts 2 may contain restrictions on the allowable effects on controlled output(s) for particular types of controls or control functions for test levels.

H.26.15.3 Different outputs and functions may be declared by the manufacturer after testing at level 2, or level 3, if relevant. Part 2 may specify particular criteria after each of these tests.

H.26.15.4 The compliance criteria shall be given in part 2 and shall be based on the operating output conditions and the functional specifications of the control under test:

a) normal performance with no loss of protective functions and control is within specification or declared limits;

b) loss of protective function within declared limits;

c) loss of protective function with safety shut down;

d) loss of protective function with unsafe operation.

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H.27 Abnormal operation

H.27.1.3

Replace, on page 439, the existing subclause H.27.1.3 by the following:

H.27.1.3 With each fault described in Table H.27.1, simulated or applied to one circuit component at a time, the control shall comply with

- the following items a) to g) inclusive. For components complying with Clause 14 of IEC 60065, the controls need only comply with items a), c), d), f) and g).

  In Canada and the USA, if a component has received qualification approval under the IECQ programme, with appropriate conditioning periods and stress factors, the faults of Table H.27.1 need not be applied.
- any additional compliance criteria, as specified in the applicable subclauses of part 2; and
- the requirements of specified software class, if declared.

  a) The controls shall not emit flames, hot metal or hot plastics, and no explosion shall result. For in-line cord controls and independently mounted controls, compliance is determined by the following test.

  The enclosure with the control therein is wrapped in tissue wrapping paper. The control is operated to steady state or for 1 h, whichever occurs first. There shall be no burning of the wrapped tissue paper. Inside the enclosure, some parts may temporarily glow, and there may be a temporary emission of smoke or flame.

In Canada and the USA, cheesecloth is used instead of tissue wrapping paper.

Integrated and incorporated controls shall either comply with the test specified for in-line cord controls and independently mounted controls or be classified as requiring, for example, further shielding, in the appliance or equipment.

b) The temperature for supplementary insulation and reinforced insulation shall not exceed 1,5 times the relevant values specified in Clause 14, except in the case of thermoplastic material.

There is no specific temperature limit for supplementary insulation and reinforced insulation of thermoplastic material, the temperature of which shall, however, be recorded for the purpose of Clause 21.

c) Any change in the controlled outputs shall be as declared in Table 7.2, requirement 57.

d) The control shall comply with the requirements of Clause 8 and 13.2 for basic insulation.

e) There shall be no deterioration of the various parts of the control that would result in non-compliance with the requirements of Clause 20.

f) A fuse in the supply, external to the control under test and as described in item d) of H.27.1.2 shall not blow unless an internal protective device also operates that is accessible only after the use of a tool.

An internal protective device is deemed not to be required if the sample still complies with the following requirements after replacement of the fuse of the supply:

- items a), b) and d) of H.27.1.3;
- the requirements of Clause 20 for the clearances and creepage distances from active parts to the surfaces of the control that are accessible when the control is mounted as for its intended use.

g) The output waveform shall be as declared in Table 7.2, requirement 56.

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H.27.1.4 Electronic circuit fault conditions

Replace the existing subclause H.27.1.4 by the following:

For the purpose of Clause H.27, the applicable failure modes are given in Table H.27.1.

Table H.27.1 – Electrical/electronic component fault modes table

Component type	Short 14)	Open 1)	Remarks
Fixed resistors			
Thin-film 13)		X	Includes SMD type
Thick-film 13)		X	Includes SMD type
Wire-wound 13) (single layer) enamelled or suitably coated		X	
All other types	X	X	
Variable resistors			
(for example, potentiometer/trimmer)			
Wire-wound (single layer)		X	
All other types	X 2)	X	
Capacitors			
X1 and Y types according to IEC 60384-14		X	
Metallized film according to IEC 60384-16 and IEC 60384-17		X	
All other types	X	X	
Inductors			
Wire-wound		X	
All other types	X	X	
Diodes			
All types	X	X	
Semiconductor type devices like transistors			
All types (for example, bipolar; LF; RF; microwave; FET; thyristor; Diac; Triac; Uni junction)	X 2)	X	3)
Hybrid circuit	4)	4)	
Integrated circuits			
All types not covered by H.11.12	X 5)	X	For IC outputs, note 3) applies
Optocouplers			
According to IEC 60335-1	X 6)	X	
Relays			
Coils		X	
Contacts	X 7)	X	
Reed-relays	X	X	Contacts only
Transformers			
According to IEC 61558-2-6		X	
All other types	X 2)	X	
Crystals	X	X	8)
Switches	X	X	9)
Connections (jumper wire)		X	10)
Cable and wiring		X	
Printed circuit board conductors			
According to IEC 60326-3	X 12)	X 11)	

[1] Only opening of one pin at any one time.

[2] Short-circuit each pin in turn with every other pin; only two pins at a time.

[3] For discrete or integrated thyristor type devices such as Triacs and SCRs, fault conditions shall include short circuit of any terminals with the third terminal open-circuited. The effect of any full wave type of component, such as a Triac going into a half-wave condition, either controlled or uncontrolled (thyristor or diode, respectively) shall be considered.

[4] Failure modes for individual components of the hybrid circuit are applicable as described for the individual components in this table.

[5] The short circuit of any two adjacent terminals and the short circuiting of

a) each terminal to the IC-supply, when applicable at the IC;

b) each terminal to the IC-ground, when applicable at the IC.

The number of tests implied for integrated circuits may normally make it impracticable to apply all the relevant fault conditions or to assess the likely hazards from an appraisal of the circuit diagram of the integrated circuit.

It is therefore permissible first to analyse in detail all the possible mechanical, thermal and electrical faults which may develop either in the control itself or its output, due to the malfunction of the electronic devices or other circuit components, separately or in any combination.

Except for types evaluated by H.11.12, a fault-tree analysis shall be conducted to include the results of multiple steady-state conditions to outputs and programmed bi-directional terminals for the purpose of identifying additional fault conditions for consideration. The failure mode "short circuit" is excluded between isolated sections for such ICs that have isolated sections. The isolation between the sections shall comply with the requirements of 13.2 for operational insulation.

[6] When optocouplers comply with 29.2.2 of IEC 60335-1, the shorting between the input and output pins is not considered.

[7] The short-circuit mode is excluded when adequate additional measures are taken to avoid contact welding or additional measures are taken to react safely to contact welding. These additional measures are under consideration.

In Canada and in the USA, the short-circuit mode is excluded for relays successfully tested to Clause 17. The successful test can be substituted by the use of a relay certified for the application.

[8] For crystal-based clocks, harmonic and sub-harmonic frequency variations affecting the timings should be considered.

[9] If switches are applied for the selection of safety times, purge times, programmes and/or other safety-related settings, these devices should function so that in the event of their opening, the safest possible condition arises (for example, in a burner control system, the shortest safety time or the longest purge time).

The short-circuit failure mode is excluded for switches successfully tested to Clause 17. The successful test can be substituted by the use of a switch certified for the application.

[10] The requirements are the same as note 11), except they are applied to jumper wires intended for clipping when selecting a setting.

[11] The open-circuit failure mode, i.e. interruption of a conductor, is excluded if the thickness of the conductor is equal to, or greater than, 35 µm and the breadth of the conductor is equal to, or greater than, 0,3 mm or the conductor has an additional precaution against interruption, for example, roll-tinned, etc. If a short circuit at the output terminals causes the opening of a printed circuit board conductor, that conductor shall be subject to an open-circuit fault analysis.

For temperature and current conditions when accepting conductor sizes, see IEC 60326-3.

[12] The short-circuit failure mode is excluded if the requirements of Clause 20 are fulfilled.

[13] These components may be used for protective impedance, if the impedance of components complies with H.20.1.9.3 and withstands the impulse voltage test of 20.1.12 for at least overvoltage category III.

[14] The conditions which have led to the design of the clearances and creepages according to Clause 20 on the assembly for which exclusion from the fault mode "short" is claimed shall be maintained over the lifetime of the control.

These conditions shall be declared or documented as follows.

Control pollution situation (Table 7.2, requirement 49)

Pollution situation in the micro-environment of the creepage or clearance, if cleaner than that of the control, and how this is designed (documentation) (Table 7.2, requirement 79)

Rated impulse voltage of the control (Table 7.2, requirement 75).

Rated impulse voltage for the creepage or clearance, if different from that of the control, and how this is ensured. (documentation) (Table 7.2, requirement 80)

The values designed for tolerances of distances for which the exclusion from fault mode "short" is claimed. (declaration and documentation) (Table 7.2, requirement 81)

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H.27.4.1 Electronic circuit fault conditions

Replace the existing subclause H.27.4.1 by the following:

The control is loaded as indicated in 17.2 and subjected to 1,15 × V_R for 5 s, when the control is providing electronic disconnection.

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J.17.18.1 Method of R/T measurement

Replace the existing note with the following requirement:

The method of measurement used (see Table 7.2, requirement 65) shall include considerations such as self-heating, thermal dissipation and voltage effect, which may produce an erroneous R/T curve.

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Annex S
(informative)

Guidance for applying Clause 20

Example A – Using annex S guidance for applying Clause 20

Replace the sixth row of the table by the following:

What is the type of insulation? (refer to definitions, etc.)	**Reinforced insulation**	**Refer to 20.1.9. For reinforced use case A and next higher impulse voltage step from Table 20.2 Record as e).**

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KEY-WORD INDEX

Replace the 12th row of the table by the following:

All-pole disconnection	2.4.1, 2.4.2, 6.9.4, 11.3.1

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